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A
SANITARY HANDBOOK
FOR INDIA

SPECIAL REFERENC[illegible] HE MADRAS
PRES[illegible]

FOR THE USE OF DISTR[illegible] [illegible]ARY OFFICERS,
MEMBERS OF MU[illegible] COUNCILS AND LOCAL BOARDS,
MEDICAL S[illegible]TS AND SANITARY INSPECTORS.

BY THE LATE

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FOURTH EDITION

REVISED AND PARTLY REWRITTEN

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PREFACE TO THE FOURTH EDITION.

It has again fallen to my lot to bring out a revised edition of McNally. The book appears to have satisfied a good many generations of students and it is hoped that the additions and alterations now made to incorporate the latest knowledge and experience will render it once again acceptable.

Its bulk has been somewhat increased, partly by added matter but principally by the use of a larger and clearer type. The object of the volume is to inculcate the principles of sanitation and, as far as possible, to give reasons for all measures recommended. Detailed descriptions of various types of sanitary structures, such as latrines, are therefore omitted. When once a student understands the principles which should guide him and the object to be aimed at, his observation of what already exists, coupled with his own intelligence, should enable him to devise something equally good, if not quite the same in detail, and, possibly, actually better. This accounts in some measure for the absence of all illustrations and plans, and it is intended that students, who naturally require concrete examples, should obtain them from the experience of their lecturer and in the course of their practical classes.

J. W. C.

Coonoor, *December* 1910.

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and a lapse into habits of uncleanness, which fully account for the terrible habitual mortality which prevailed and the awful epidemics which periodically swept over Europe during the middle ages. Mankind had once again to be taught by dire experience, and from its teachings gradually arose the fabric of modern hygiene.

A few facts may now be cited from the recent history of England to show what can be accomplished in a comparatively short period by sanitary reform. Seventy years ago, England was little more advanced in public sanitation than India is at the present day. Impurity of air, water, and soil was the rule everywhere ; vaccination was not general ; sanitary law was all but unknown ; no facilities existed for towns or districts to borrow capital for public improvements ; there was no general registration of vital statistics. The Registration Act of 1837 was the *Magna Charta* of sanitary reform in England, and the able and logical reports of the Registrar-General (Dr. Farr's first annual report appeared in 1839) did more than anything else to place England in the foremost rank of healthy nations. Activity in the prosecution of sanitary works became prevalent all over the country, and the good effect of measures, such as improvements in drainage, sewerage, water-supply, food, dwellings, is abundantly shown by the great and progressive decline of mortality which immediately followed them. Numerous instances are cited in the reports of the Registrar-General, and of the Medical Officer of the Local Government Board, which show that such a local decline invariably followed local sanitary improvements. The money borrowed for sanitary works in Great Britain between 1848 and 1886 amounted to no less than £130,000,000, in addition to large sums provided out of local revenues and enormous private

expenditure. But this money was well invested. The average duration of human life in Great Britain has been largely increased,* and this, coupled with the prevention of sickness, has added enormously to the productive power of the population and the wealth of the nation. The yearly death-rate of London, which closely approaches the average English death-rate and was 50 per 1,000 in the 18th century, steadily diminished until it reached but 22·4 in the ten years 1871–80, and 19·3 in the five years 1881–85, and several English districts have now a death-rate below 15 per 1,000 —a rate which not long since was regarded as utopian. When allowances were made for differences of age and sex constitution, it was found that about one-sixth of the whole population of England during 1881–1890 lived in districts with a death-rate below 15 per 1,000.

When to these saved lives is added the avoidance of at least four times as many attacks of non-fatal illness, we have the total profits as yet received from the sanitary expenditure. Considering the amount of preventible disease which still exists and the amount of sanitary work which is practicable in the way of improving local conditions and habits and preventing the spread of disease, it must be regarded as possible for the mortality of the United Kingdom as a whole to be still further reduced.

Similar results can undoubtedly be attained in India, and India has this general advantage over England that she possesses proportionately few large towns. The introduction of purer water-

* The mean duration of life (expectation of life at birth) was, in round numbers, by Price's Northampton Life Table corrected (1762) about 30 years, by Milne's Carlisle Table (1789) 38 years, by Farr's English Life Table, No. 1, (1841) 41 years, and by Dr. Ogle's New English Table (1871–80) 43 years. According to the experience of 1881–1890 it was 51–52 years.

supplies has caused a large reduction of cholera mortality in Madras, Calcutta, and some other towns; the great improvement of health among soldiers and prisoners in cases where a faulty dietary has been corrected is well known; and other instances might be mentioned where sanitary measures have been followed by a reduction of mortality in India. For the sake of comparison it may be mentioned that, whereas the expectation of life at birth in England is now about 44 years, equivalent to a death-rate of 22·7 per 1,000 per annum, in India the expectation is only about 40 years, the equivalent of a death-rate of 25 per 1,000.

It has been reckoned that nearly four-fifths of the entire registered mortality of India is due to mitigable or preventible diseases.* The statistics of the general population are unreliable owing to imperfect registration, but those of Municipal towns are more to be depended on. In the Municipal towns of the Madras Presidency for the five years 1901-1905 the average registered annual mortality exceeded 34·7 † per 1,000, and nearly half of this mortality was attributed to the four causes—cholera, small-pox, fevers, and bowel-complaints; the first two of which ought to be entirely preventible, and the two latter preventible to a great extent. Besides these, other preventible diseases account for a portion of the remaining mortality. Altogether there is no doubt that Indian mortality can be very largely reduced, and that the happiness and prosperity of the people will increase with their longevity.

The scope of preventive medicine is by no means limited to the control or extermination of the few well-known diseases which are endemic or occur

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* Army Sanitary Commission, 1886.

† The true rate was probably about 40.

as epidemics, such as cholera, small-pox and malaria. It may be taken as fact that all diseases, not excepting hereditary influences, are preventible, had we only full and accurate knowledge as to their causation. Death need occur from no causes but accident and old age.

It is impossible at present in any country to estimate the number of deaths which result either from purely senile decay, that is functional failure due to atrophy, apart from any morbidity, or under wholly accidental circumstances, but the figure is probably remarkably small, and no reasonable conjecture can therefore be made as to the possible expectation of life in man under the most favourable conditions imaginable.

No knowledge of the innumerable influences which bear on the conditions of life can be outside the range of the worker in the prevention of disease, and under this heading the social reformer can be included as an instrument as efficient as the Sanitary officer.

Too great importance is attributed at the present day to the treatment of individual cases of disease, and far too little to the organized study of the conditions which give rise to the more important classes of disease. In other words the sympathy extended by the world in general to a sick man, though meritorious as a human quality, cannot be counted as a characteristic of perfect altruism; rather it is in great measure dependent on a misconception of the true relation of the sick man to the mass of human beings who are not sick.

In an outbreak of cholera, which is the more meritorious action, to overflow with sympathy for the agonies of the unfortunates attacked and to devote one's whole energies to alleviating their sufferings, or to neglect the actual sufferers and to endeavour to locate the source of infection, and

thereby to save many others from falling victims? If money and hands are available, by all means let both be done simultaneously, but if a choice has to be made, the course which ultimately benefits the majority is obviously the right one to follow, even though suffering must be unheeded on the way.

Enormous sums of money are spent in the alleviation of suffering all over the world at the present day, and no one can assert that it is not well spent. No one, however, can deny that it is the case of the individual which is occupying attention and not the case of mankind in general, and that the same sum spent in prevention would probably benefit a much larger number of persons in saving them from sickness. Far less money is now spent on preventive measures than on treatment, and this is largely due to the fact that preventive measures can only be carried out by governing bodies and not by private individuals; whereas treatment is offered both publicly and privately. A livelihood cannot be made by preventive work except by State-paid officials, but those who offer treatment secure a return for their services.

In the area of British India under registration in the year 1907, the general death-rate was calculated to be 37·18 per 1,000. During the same period the death-rate from cholera was 1·81, from small-pox ·46, dysentery and diarrhœa 1·25, fevers 19·76, plague 5·16 per 1,000.

So far, active preventive measures have been taken against no other diseases, except in isolated instances which may be neglected as having no influence on the general rate. Supposing that cholera, small-pox, dysentery and plague had been entirely exterminated, the general death-rate would only have been reduced by 3·52 per 1,000, but nearly 800,000 lives would have been saved. Even

with this reduction the rate of 33·66 per 1,000 would leave much to be done.

Poverty is undoubtedly a great bar to sanitary improvement, and bad sanitary conditions beget poverty, so that poverty and sickness re-act upon each other and tend to diminish the vital power of a people and their capacity for improvement. Hence the task of initiating sanitary improvements must devolve upon the governing, educated and wealthy classes of a community; and, apart from the higher motive of philanthropic duty in relieving the sufferings and ameliorating the lot of their poorer, more ignorant and dependent brethren, it is manifestly their personal interest to ward off disease from their own doors. Not rarely do epidemic diseases such as cholera or small-pox, whose breeding places are in the midst of dirt and poverty, leave their endemic haunts among the poor and seek out their victims in the neighbouring houses of rank and opulence. Then indeed, spasmodic efforts are inspired by terror, and money is often frittered away in fruitless efforts to stay an epidemic, which wiser forethought would have prevented.

Hurried whitewashing and cleaning up can do little to purify places where earth, water, and air have been habitually defiled, to establish effective control over unwholesome food supplies, or to reform the insanitary habits of generations. Deliberate training and preparation are as necessary to protect a country against the invasions of disease as to fortify it against the inroads of an enemy, and all experience proves that sanitary preparations protect from endemic as well as from epidemic diseases. Sanitary preparations should, therefore, be steadily prosecuted at all times, and we may rest assured that as we lessen our mortality from ordinary endemic diseases, so do we diminish our

liability to the ravages of epidemics; but, while urging that sanitary improvement should be prosecuted steadily at all times and not only fitfully under the influence of panic produced by unusual outbreaks of disease, it should not be forgotten that it is a wise axiom not to destroy existing arrangements, faulty though they may be, without having provided efficient substitutes.

It is not until the masses of the population have assimilated the fundamental principles of hygiene, until the poorest and least educated have learnt instinctively to recognize dirt when they see it and to realize the dangers to health and life of insanitary surroundings, until what has been called a "sanitary conscience" is a common possession, that a really satisfactory state of affairs can be considered to be inaugurated. This end can never be attained without the proper tuition of the young in sanitary matters, and the inclusion of the rudiments of hygiene amongst the subjects taught in the elementary schools of all countries is not only advisable but imperative. A few important facts implanted in the mind of a child are more likely to influence him in afterlife in the direction of understanding what he should do and should not do in order to preserve health and avoid disease, than the promulgation of the most elaborate sanitary regulations amongst adults, who have not had the advantage of this early training.

The duties of the sanitarian require a combination of reason and firmness, tact and skill. It is only by earnest and sustained exertion that any permanent improvement can be effected, and constant vigilance is required to prevent deterioration and relapse. Unwearying attention to details is a necessary condition of success in sanitary administration, and the most indomitable perseverance is

needful for the pioneers of sanitary work. Zeal must, however, be tempered with discretion, and, in dealing with ignorant or interested opposition, tact and compromise may largely succeed when haste and impracticable thoroughness must totally fail. Small and partial measures can often be carried out where larger and more comprehensive ones are impossible, and small and partial measures of improvement are not by any means useless. They are steps on the road. Every single case of disease prevented or mitigated is so much gained and may be the cause of preventing thousands of other cases. As every little loophole which is barred against the entrance of an enemy strengthens the citadel, so does the stoppage of every single channel by which disease may enter or be propagated strengthen the structure of public health.

Public health is one of the most serious concerns of the State. Bad sanitary conditions lessen the working power of an individual by constantly lowering his strength and energy, by causing periods of sickness when he cannot work at all, and by shortening his life. It is a fact which hardly needs demonstration that, other things being equal, a healthy long-lived community has enormous advantages over an unhealthy short-lived one, inasmuch as it possesses a larger proportion of working adults. This alone would ensure its supremacy in any commercial or military struggle. But furthermore its incapacity from sickness must also be much less, and its people must be more vigorous at all times. It is, therefore, apparent that good sanitation is an important element of national prosperity, and that, on economical grounds alone, it is to the advantage of communities and governments, as well as of individuals, to do all in their power to promote it. Indeed, the economical value and national importance of State medicine can hardly be overestimated.

In the words of the President * of the International Congress of Hygiene at Vienna in 1887,—"Man is the most precious capital of the State and of society in general: every individual life represents a certain value."

The duty of the State and of the influential and wealthy classes to initiate and promote sanitary improvements being acknowledged, an important consideration yet remains: one of the most essential factors in the sanitary progress of a community is the co-operation of the people themselves. The efforts of Government and of enlightened local authorities are often rendered more or less abortive by the passive resistance of the mass of the population. This resistance cannot usually be regarded as culpable; it is but the natural outcome of ignorance—more often a misfortune than a fault—and it is the first duty of every medical and sanitary officer, from highest to lowest, of every member of a municipality or local board, and of every other person who possesses the requisite knowledge, to assist in dispelling the darkness of ignorance which degrades the people and renders them a constant prey to misery and disease. Local illustrations are most apt to impress uncultivated minds; for instance local outbreaks or single cases of a disease, in which it can be shown that the incidence of the disease is dependent upon some form of sanitary negligence, are certain to impress them more than facts which are not obvious before their very eyes.

Combined action and public legislation are not only requisite for the execution of large sanitary undertakings, but they are equally necessary to protect individuals and communities from disease in the daily affairs of life. It is the interest of every individual not only to obey sanitary precepts himself,

* The Crown Prince Rudolf of Austria.

but to see that his neighbours do so likewise. A single individual may, by his own wise conduct, ward off much disease and misery from himself; but he cannot live apart from his fellows, and is very apt to suffer disease, and perhaps death, entirely owing to their sanitary sins. They may poison his air, his water, and his food, or sow broadcast the germs of communicable diseases: he is forced to share the results of their folly. Similarly the insanitary acts of one individual may affect a whole community; therefore every individual who commits a sanitary offence is a public criminal of the worst kind, for his hand is against every man. Hence the necessity of punitive sanitary law.

Besides those objections to sanitary improvement, which are the result of ignorance, indolence, or fatalism, one other deserves special notice, because it is the only objection of a scientific nature which has been advanced. A partial application of Darwinian principles has led to the conclusion * that sanitation interferes with natural law, and that degradation of the human race must be the result of a suspension or abrogation of disease as a cause of natural selection and the survival of the fittest. It may be pointed out that this objection would apply to curative more aptly than to preventive medicine. Its confutation, however, must rest upon evolutionary principles. The fact is certain that insanitary conditions affect not only the weakly, whom they kill, but the strong, whom they debilitate, and, in this way, they tend to produce a depraved race; whereas improvement in sanitary conditions, according to the doctrines of the influence of environment and improvement under improving conditions, must tend to improve the race. It might be conducive to improvement—

* A conclusion which has been partly supported by the great authority Herbert Spencer.

unless the race were totally wiped out by the process—if individuals attacked by diseases which permanently enfeebled them were all to die, and thus be prevented from propagating a feeble offspring ; but it is a fact that, for each one who dies, a considerable number recover with more or less damaged constitutions ; such diseases being unchecked must, therefore, necessarily tend to cause degeneration of the race. On the other hand, the aim and effect of sanitation is to prevent the enfeeblement of individuals by disease, and not only to act thus, in a negative way, by preventing deterioration of the race, but also to act positively towards the improvement of the race by improving their surroundings and their mode of life. Practical illustrations of the truth of these doctrines may be observed everywhere. Persons and communities who live under the best sanitary conditions are notoriously the most vigorous ; those who live in the country are more vigorous than others of the same race who live in towns under inferior sanitary conditions ; those who live on high lands, where the soil is comparatively dry and the air and water pure, are more vigorous than those who live on ill-drained low lands ; the unhealthy life conditions of the inhabitants of malarious tracts in South Canara and the Wynaad have produced a puny, stunted, short-lived and degenerate race, who compare unfavourably in every way with the inhabitants of healthier localities in the neighbourhood. Drainage and improved ventilation have enormously reduced the prevalence of phthisis in many parts of England to the obvious benefit of the race. From these and innumerable other examples of the kind the conclusion is inevitable that the aim of the sanitary evolutionist should be not to deprave the race by adapting it to unhealthy surroundings, but to elevate it by improving its surroundings.

Nevertheless it must be admitted that by means of medical and sanitary improvements many enfeebled and degenerate individuals who, amid less favourable surroundings, would not have survived, have been preserved and enabled to propagate their species. The offspring of such degenerate parents seldom develop into worthy citizens, and questions are now arising as to how far a State, whose aim is self-preservation and healthy development, is justified in permitting marriages among the unfit and the birth of a class which will never be of use but merely a drain on its resources. A full discussion of such matters is, however outside the scope of this hand-book.

CHAPTER II.

FOOD AND DIET.

Physiology of Food.

The uses of food are: firstly, to supply material for building up the tissues of the body in early life, and for repairing them and making good their waste (which may be compared to the wear and tear of machinery) throughout the whole course of life; and secondly, to supply fuel for warming the body and for its internal and external work.

Composition of the body.—The tissues of the body are composed partly of *inorganic* or mineral matter, and partly of so-called *organic* matter or that which is always associated with life. About 58 per cent. by weight of the body is water.

The mineral matter consists chiefly of salts of the metals, sodium, potassium, calcium and, in much smaller quantities, iron and magnesium; these are partly free and partly in combination with the organic matter.

The organic matter is composed of various combinations of carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus, and may be roughly divided into the proteid or nitrogenous group and the fatty or non-nitrogenous group.

The nitrogenous group comprises all the active cellular elements of the organism, while the non-nitrogenous is mainly subservient.

Fat is contained in nearly all the tissues, and masses serve to pad and protect internal organs, to lessen the friction of the muscles, to form a warm

covering like a blanket under the skin, and to function as a store of energy which may be drawn upon and consumed when food is deficient.

Requirements of the body.—All of the above groups must be represented in the food which is taken into the body, for one cannot supply the place of another. The energy of the body is due to complex chemical changes which are constantly taking place in the innumerable cells which go to give it form. For their mere existence the cells require a constant supply of assimilable nourishment; to enable them to perform their multifarious functions a further supply is needed.

To maintain life in the body as a whole, a considerable output of energy in the form of internal work occurs unconsciously. The heart never ceases to beat, the muscles of respiration never cease to contract; the muscular system of the alimentary canal is in constant action, the brain and other organs are always at work and there is the temperature of the body to be kept at what we call its normal level. All this expenditure of energy has to be made good by the consumption and assimilation of food stuffs which is aided by the oxygen derived from the air breathed in.

No chemical process results in the annihilation of matter. If energy is set free in a chemical process, it is only because a complex substance is broken down into one or more less complex compounds, and, if it were desired to build up the original complex from its simple and separate components, precisely the same amount of energy would be absorbed as is set free when the complex is broken down. It is by the breaking down of complex food stuffs into comparatively simple compounds that energy is set free in the body, and these simple compounds being of no further use to

the body as sources of energy are discharged in various ways, (1) by the lungs, the waste carbon of the food passing out in the breath in the form of carbon dioxide, and the hydrogen as water vapour; (2) by the kidneys, waste nitrogenous matter, salts and water leaving the body in the urine; (3) by the bowels, the indigestible portions of the food being evacuated; (4) by the skin, which to some extent supplements the action of the kidneys and the lungs.

Constituents of Food.

The chemical constituents of food substances have now to be described with special regard to their use for the nutrition and repair of the tissues and as fuel for the production of animal energy.

The substances used for food may be classified thus:—

Organic ...	Nitrogenous.	Proteids (albumin, globulin, etc.). Albumenoids (mucin, gelatin, etc.).
	Non-nitrogenous.	Carbohydrates (sugars, starches, etc.). Hydrocarbons (fats and oils). Vegetable acids.
Inorganic ...	... ...	Mineral salts and water.
Food accessories	... ...	Condiments. Flavouring substances. Tea, Coffee and other beverages.

Water ~~is~~ an essential constituent of all food and, taken partly in solid food and partly as drink, should form at least four-fifths of the total weight consumed. Milk, which is the natural food of infants, contains 88 per cent. of water. Most raw food-grains contain one-eighth their weight of water, and, when boiled, more than half. Water

forms about three-fourths of the weight of lean meat; and succulent vegetables contain much more; melons, for instance, 90 to 95 per cent. The use of water is to soften and dissolve the solid constituents of food, so that they can be digested and absorbed.

Mineral ingredients, or salts, are contained in all foods, and constitute the whitish ash which remains when a food substance is burnt. Rice is the only important food in which they are very deficient. Calcium and potassium phosphates, salts of organic acids, and traces of iron salts are the most important salts contained in food. Common salt (sodium chloride) is also essential, and, being contained in only small proportion in most foods, has to be added separately. Some of these salts are necessary constituents of the fluids of the body and assist in the processes of digestion and in the formation of bony and nervous tissues. The salts and acids contained in fresh vegetables and fruits are useful in preventing scurvy. About half the quantity of mineral matter required is contained in the food substances, the other half being added in the form of common salt.

Proteids and *albumenoids*, also termed *nitrogenous* or *flesh-forming* substances, are the most important and the most apt to be deficient of the solid constituents of food. They are contained in very different proportions in various articles of food, and are most abundant in animal foods and in the seeds of leguminous plants. Proteids are not only indispensable for the nutrition and repair of the tissues, but they may also take the place of carbonaceous foods (oil and starchy constituents) and serve as fuel for the production of energy.

Oils, or fats, consist of carbon and hydrogen with very little oxygen. A moderate quantity of

oil in food, though not essential to life, is conducive to health and proper nutrition. Most articles of food contain a little oil, but it is usually necessary to add more. Animal are more readily digested than vegetable oils. Oil is a most valuable source of energy, being nearly two-and-a-half times as powerful as starch.

Starchy constituents, including sugar and some other substances, are sometimes termed *carbohydrates*, because they contain, united with carbon, such a proportion of hydrogen and oxygen as together would form water. *Starch* is the principal carbonaceous food of mankind. The staple grains, which form the great bulk of human food, are composed principally of starch; arrowroot and sago consist entirely of it; and some other vegetable foods contain considerable quantities of it. Starch exists in plants in minute granules, which can only be seen by the aid of a microscope, and which differ in size and shape in each plant. To render starch easily digestible and fit for food these granules have to be burst by cooking. By strong heating, as in parching grain, starch is converted into *dextrin* which is more soluble and easily digested. *Sugar* has nearly the same value as starch as a source of energy. *Cellulose*, of which the fibres and cell walls of plants consist, belongs to this group of substances. More or less of it is taken with all vegetable foods; but it is indigestible and passes away through the bowels.

Condiments or flavouring constituents.—Besides the essential constituents of diet, various substances are employed to give flavour and variety to food, to stimulate the digestive organs, and to act as antiscorbutics. These commonly consist of seeds, fruits, leaves, or other vegetable product containing essential oils, or of acid substances, as tamarinds, limes, vinegar.

A knowledge of the part taken by the element nitrogen which forms about 79 per cent. of the gases of the air is of value in understanding the subject of food and diet. Nitrogen is an essential constituent of living matter; it is present in every animal tissue and fluid and in all the living parts of plants. Without it there can be no life, and unless it is supplied in adequate quantities and in a form in which it can be assimilated, both animals and plants cease to exist. The great source of nitrogen is the air, of which it is the chief constituent, but, with the exception mentioned later on, it can be abstracted from the air by neither animal nor plant. Both animals and plants respire, but, though they utilise the oxygen of the inspired air, they cannot utilise the nitrogen. Animals obtain the nitrogen they require by digesting the complex albuminous substances eaten as food, both animal and vegetable, but they cannot utilise the nitrogen found in simple mineral salts. Plants, on the other hand, obtain their nitrogen by absorbing from the soil through their roots simple mineral salts containing nitrogen, and they cannot utilise the nitrogen contained in complex organic albuminous substances. Hence crops rapidly exhaust the soil, and manuring the land, *i.e.*, supplying it with a fresh stock of plant food, becomes a necessity. This manure is either artificial or natural, the artificial consisting of simple mineral salts which can be readily utilised by plants, and the natural, of waste organic nitrogenous matter which becomes disintegrated in the soil and its complex albuminous substances split up into simple salts. The process of disintegration is carried out by the agency of the nitrifying micro-organisms of the soil, to which we shall again have occasion to refer when we come to the discussion of the disposal of refuse. Thus we see that dead animal and vegetable matter is rendered fit food for plants by the

action of these soil organisms, and the plants in their turn form food for animals, and the waste of animals goes to recuperate the soil, and thus the cycle of life goes on.

A few years ago it was found that a certain class of plants, the *leguminosæ*, which includes the peas, beans, and such like seeds, was able to grow on a soil which had been exhausted of its nitrogen by other crops. Investigation proved that a micro-organism living symbiotically in nodules on the roots had the power of fixing the nitrogen of the air and enabling the plant to absorb it. So here we have the only natural process known by which the inexhaustible store of atmospheric nitrogen can be rendered available for entering into either animal or vegetable life.

Requirements in Diet.

Proportions of constituents.—Diet requisites vary to some extent with circumstances which will be mentioned further on. To understand the principles of diet we must, firstly, consider the relative quantities or proportions of food constituents, and, secondly, the absolute quantities which are required. We have seen that the main functions of food are to supply (1) nourishment and (2) energy. Considered in this light the chief food constituents may be divided into two groups: (1) nitrogenous substances (proteids), (2) carbonaceous substances (fats, starches, sugars). In estimating the value of a food, it is convenient to consider all the carbonaceous constituents as if they consisted of starch only. For this purpose the weight of fat should be multiplied by 2·4, to get its equivalent of starch, and this should be added to the weight of the starchy constituents. Thus the *proportion* between the nitrogenous and carbonaceous ingredients may be easily observed.

In a good diet the ratio should not be less than 1 : 6; that is, *for every six parts of carbonaceous there should be at least one part of nitrogenous material.* This rule is founded upon practical experience as well as upon physiological considerations.

A second general rule, though one of less importance than the first, based on similar grounds, is, that *at least a similar proportion* (1 : 6) *should exist between the fat* (reckoned as starch) *and the total carbonaceous constituents* reckoned as starch.

To state the matter in the usual way, the following figures show the smallest relative quantities of nitrogenous and fatty to starchy constituents which may be contained in a good diet *:—

Starchy 15.	Nitrogenous 3.	Fatty. 1.

While smaller proportions than these of nitrogenous and fatty substances should not be contained in a good diet, there are certain circumstances under which the proportions of these alimentary constituents may be increased with benefit. The question of the proportions of the various constituents of food stuffs which are needed to produce the best results is still a matter for controversy and experiment.

Some tropical races live chiefly on rice, milk and ghi, others use either meat or fish or eggs, or all three in addition; some subsist mainly on millets, others on wheat, while yet others eat little but meat. As a general rule the diet adopted is the cheapest

* The approximate composition of the different classes of foods is—

—	Nitrogen.	Carbon.	Hydrogen.	Sulphur.
	PER CENT.	PER CENT.	PER CENT.	PER CENT.
Proteid	16	50	1·8	1·4
Fat	...	75	11	...
Carbohydrate ...	...	40—45	...	...

local product: it does not follow that it is the most suitable or that it produces the finest race possible under the circumstances; that can only be learnt by experience when all classes of food are available, but it shows the adaptability of the human species to local conditions.

The daily waste of a man weighing 70 kilogrammes doing moderate work is about 20 grams of nitrogen and 320 grams of carbon. This has been ascertained by careful experiment and gives the ratio of 1 nitrogen to 16 carbon. Proteids contain 16 per cent. nitrogen, so that 125 grams of proteid must be consumed daily by such a man if 20 grams of nitrogen have to be supplied to make up for the quantity excreted.

The recently conducted experiments of Chittenden in America show on the other hand that, instead of from 100—150 grams of proteid being required daily, health, strength and athletic fitness can be secured by a reduction of this by 50 per cent. On such a diet the excretion of nitrogen was reduced to 6—10 grams.

Chittenden's ratio of nitrogen to carbon works out at 1 to 10 which may be compared with the 1 to 6 which has hitherto been accepted as the optimum.

In the case of Japanese coolies the ratio is 1 to 8 or 10 and of Madras coolies on a rice diet 1 to 9.

Other circumstances exert an influence on the proportions of the constituents of food which are from time to time needful.

Variations in Youth.—In the diet of the young and growing child a higher proportion of nitrogen and fat is required to afford material for building up the tissues of the body.

Human milk, which is the natural diet of infancy, contains nitrogenous and carbonaceous constituents

in the proportion 1 : 3·5 and nearly half the weight of the carbonaceous constituent is fat. As age advances these proportions may be gradually reduced, especially as regards fat; but it should not be forgotten that, until growth is complete, the diet of young persons ought to contain a larger proportion of nitrogenous and fatty constituents than that of adults.

A frequent error in feeding children is to give them too large a proportion of starchy food, and thus, though their stomachs may be over-distended with an excessive quantity of food, they are ill-nourished and unhealthy. Children also need a sufficient supply of lime salts in their food to afford material for the formation of their bones and prevent the occurrence of rickets.

Variations due to Habit may cause life to be supported wholly upon nitrogenous and fatty foods, to the exclusion of starchy materials. The inhabitants of cold and wild regions, where animal flesh and fat are almost the only food obtainable, afford instances of this habit. Persons unaccustomed to the use of starchy food do not easily digest it; and those whose staple food is starch may find it difficult to digest sufficient quantities of fatty and nitrogenous materials to supply its place. Therefore great and sudden changes in the habitual proportions of food constituents are to be deprecated.

Variations due to Climate.—It is obvious that the portion of the food which is required to maintain animal heat by its slow combustion in the body need be much less in hot than in cold climates, and in hot than in cold weather. Hence a large proportion of fatty food is particularly useful in cold climates, as it supplies the necessary fuel in a less bulky and more readily digestible form than its equivalent of starch.

Variations due to Work.—When unusually hard work has to be done, an addition of fatty food or the substitution of fat for some of the starchy constituents of diet is very useful for the same reason as that above stated. A proportionate increase of nitrogenous food is necessary at the same time, because carbonaceous food cannot be properly digested without such an admixture.

Variations in Sickness.—The proportion of alimentary constituents in diet is often of great importance in the treatment of disease, but a consideration of this subject belongs properly to the physician and cannot be discussed here.

Diets may be faulty by relative excess or deficiency of certain constituents. A common fault in the diets of both rich and poor in India is a deficient proportion of nitrogenous matter.

The consequence is that, to supply a sufficient quantity of this for the ordinary nutrition of the body, a large excess of carbonaceous matter is habitually consumed. The effect of such a diet is to produce improper nutrition of the vital tissues, with an undue deposit of fat, frequent indigestion, and sometimes fatty degeneration of organs or diabetes. For instance, rice contains only 1 part of nitrogenous to 11 of carbonaceous material; and, as the lowest proportion for a good diet is 1 : 6, it follows that, in a diet consisting exclusively of rice, if only a bare sufficiency of nitrogenous aliment is taken, nearly double the necessary quantity of carbonaceous material must be swallowed at the same time. In other words, two pounds of rice have to be taken to do, in an imperfect manner, the work of one pound of a correctly constituted food. It is obvious too that the intestines are unduly burdened by having to contain this mass of vegetable matter, and that the individual is wasting energy by carrying

about from day to day a weight of material inside him much of which consists of waste and indigestible matter.

Excess of certain salts may occasionally be injurious, as when excess of lime salts induces stone in the bladder. On the other hand, deficiency of such salts may lead to rickets in children, and to defective nutrition of nervous and other tissues. Deficiency of common salt may cause indigestion and encourage the breeding of intestinal parasites.

A due proportion of fat is not so essential as a sufficient proportion of nitrogenous material in food, because some fat can be formed in the body from other constituents of food. Only a limited quantity, however, can thus be formed in the human body, and a certain proportion of fat is therefore required in every good dietary. An excess of fat, particularly if it be vegetable, and if the total amount of food be in excess, is apt to produce dyspepsia and diarrhœa in persons not accustomed to it; but, if taken habitually, it is likely to cause obesity. Fat is particularly required as an adjunct to food consisting of starchy and albuminous substances which are deficient in it.

The Quantity of Food required.—The daily quantity of dry food materials required by an adult during idleness is about 0·15 oz. for each lb. weight of the body, or, in other words, $\frac{1}{105}$ of the body weight. A man weighing 105 lbs. and doing no active work will therefore require 1 lb. of dry food constituents daily. At least 2 oz. of this should be nitrogenous material, 0·75 oz. of fat (which is equivalent to 1·8 of starch), and 0·7 oz. salts. The daily quantities in a subsistence diet for an idle man weighing 105 lbs. would thus be in ounces—

Starchy	11·5
Nitrogenous	2·0
Fatty	0·75
Salts	0·75

If fatty constituent cannot be given, the quantity of starch should be increased to 13·25 oz.*

These quantities must be increased or diminished in proportion to body weight. There are other circumstances besides the weight of the body which may modify, more or less largely, the quantity of food which is required. These are youth, work, habit, climate.

Quantity of food in relation to age.—During growth much more food is required, in proportion to weight of body, than in adult life. It has been already mentioned that this food should also be more nitrogenous and fatty. The total daily quantity of dry food constituents needed by an infant may be stated as 0·6 oz. for every 1 lb. of body weight or about $\frac{1}{26}$ of total weight. At 10 years of age the quantity will be about 0·3 oz. per 1 lb., or $\frac{1}{50}$ of total; and after puberty, about 0·2 oz. per lb. or $\frac{1}{80}$ of total weight until growth is complete.† For subsistence a man requires 0·1 oz. of water free food for each pound of body weight, and for ordinary work about 0·7 oz.

Quantity of food in relation to work.—The relation between food and work is of the highest importance. It is a matter of daily experience that increased work requires increased food. Men, like

*

Dry, *i.e.*, water free.	Rest.	Ordinary work.	Hard work.
	oz.	oz.	oz.
Proteids	2·5	4·5	6·5
Fats	1·0	3·9	5·0
Carbohydrates	12·0	14·0	16·0
Salts	0·5	1·0	1·5

† These deductions are made from Letheby's figures.

other animals, lose weight by consuming the tissues of their own bodies, if their food does not bear a sufficient proportion to the work which they do, until ultimately they succumb to disease or become unable to accomplish so much work. As fuel in a steam engine may, by its combustion, supply mechanical energy, so may food, in the animal body, by a chemically similar, though slower, combustion, supply mechanical energy. The animal body is a more perfect machine than the steam-engine, for while in the latter only $\frac{1}{10}$ of the theoretical energy of the fuel can be utilized as mechanical work, fully $\frac{1}{5}$ of the energy of man's food can be realized.*

The amount of energy that can be obtained from a given weight of matter is proportional to the amount of heat given out during its combustion. This heat is measured by the standard unit called the "calorie" and is the quantity required to raise the temperature of 1 lb. of water 1° Fahrenheit. Converted into mechanical energy a calorie is equivalent to the work done in raising 772 lbs. 1 foot high, or, as it is generally called, 772 foot-pounds of work. When using large numbers it is found convenient to convert the pounds into tons, and the work done in raising 1 ton 1 foot high is spoken of as one foot-ton.

Just as a given weight of coal or wood, when completely burnt up, gives out a definite quantity of heat which can be measured and stated as mechanical energy, so do given weights of foodstuffs, when entirely consumed, give off definite quantities of heat which can be expressed as mechanical energy. The value of foodstuffs as power producers corresponds, therefore, with their value as heat producers,

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* Helmholtz.

and now that the heat equivalents of most food materials have been worked out and tabulated, it is possible to get a fair idea of their respective nutritive values. Such tables cannot be taken, however, as showing the exact value of the different substances from the point of view of nutrition, since the digestibility and assimilability of the foods in the body have to be taken into account; still they form a uniform basis for comparison.

The internal work performed in the body during 24 hours has been calculated to amount roughly to—

242	foot-tons for maintaining the circulation.
39	do. do. respiration.
2,519	do. do. the bodily temperature.
2,800	

This quantity of energy must be supplied by the food if mere existence is to continue, and external work is not provided for at all. 300 foot-tons is reckoned to be a fair day's work for an average man. In order to perform this, since $\frac{4}{5}$ of the energy expended in doing work is lost as heat, five times that amount of energy is required to be available. So that the amount of energy that must be supplied by the food daily is—

	2,800	foot-tons for external work.
(5 × 300)	1,500	do. do.
Total ...	4,300	

150 foot-tons a day is a light day's work, and is about the amount done by a man who does the ordinary business of life without manual labour. 600 foot-tons is a very hard day's work which cannot be maintained for many days in succession by ordinary people. To give an idea of what this

means, it may be stated that a man walking at the rate of 3 miles an hour along the level does work equivalent to raising $\frac{1}{20}$ part of the weight of his body through the distance walked. If he carries a weight this has to be allowed for, and if he ascends a hill the height has to enter into the calculation. Assuming that a man weighs 120 lbs., in walking one mile under the above conditions he does work equivalent to lifting 14 tons 1 foot high, and in walking 20 miles 280 foot-tons. If at the same time he carries a weight of 40 lbs., he does 18 *plus* 280 foot-tons of work.

In a standard diet the proportions of foodstuffs are—

Proteids ...	100	Carbohydrates ...	315
Fats ...	65	Salts	23

and the energy derivable is about 4,000 foot-tons.

The mechanical value of the different classes of food may be reckoned as follows :—

1 oz. dry albuminate (proteid) yields about 173 foot-tons of potential energy.

1 oz. dry fat yields about 378 foot-tons of potential energy.

1 oz. dry carbohydrate yields about 135 foot-tons of potential energy.

So we see that the fat stands highest in the scale as a source of energy. In order, however, that nutrition may be properly carried on it is necessary that the different classes of food be eaten in due proportions as indicated above in the standard diet. From these data the additional amount of food required for any additional amount of work may be easily calculated, always remembering that five times the theoretical amount of food must be taken, as

only one-fifth of its potential energy is actually realizable.

Two foot-tons for each pound weight of the body is a fair day's work for a man, 3 foot-tons per pound is hard labour. From the data given above, it may be calculated that for 200 foot-tons of work a man may properly receive the following addition to his subsistence diet:—

	oz.		oz.
Carbohydrates ...	5·0	Fat	0·5
Proteids ...	1·0		

Quantity of food in relation to habit.—Most people who can afford it eat considerably more food than they require and assimilate only the more easily digestible portions of their food. If the food of such over-fed persons be suddenly diminished to about their actual needs, they will be partially starved at first, owing to their being unable to digest all the nutriment of their food. Again, grain-eaters, who are accustomed to distend their stomachs with large quantities of food containing far too much starch, though perhaps not a sufficiency of proteids, will at first suffer from hunger if their diet be changed for a less bulky, although more nutritious one.

Quantity of food in relation to climate.—In cold climates, as already mentioned, more food is required than in warm climates because more is needed to maintain the heat of the body, supposing the amount of work done to be the same.

Deficiency of food.—The withdrawal of food, if sudden and complete, is followed by great weakness, and wasting of the fat and other tissues of the body. Under favourable circumstances a person may live for about three weeks without food, but death generally occurs in less than half that time.

Exhaustion supervenes very rapidly if hard work be done without food.

Excess of food is habitually taken by many people without any very obvious ill-effects, the unused excess passing away by the bowels. Great excess, however, leads to an unhealthy plethoric condition, with digestive troubles, and a tendency to structural degeneration or other diseases of various organs, for instance, of the liver or the kidneys.

Food Materials.

Hitherto we have been considering the more theoretical aspect of food and diet: we have now to see how the scientific principles of diet are to be practically applied.

Natural food substances may be classified thus :—

1. Staple food-grains.
2. Leguminous grains.
3. Animal foods.
4. Oils and fats.
5. Starches and sugars.
6. Vegetables and fruits.
7. Condiments.

In the following paragraphs some account is given of the principal substances contained in each of the above classes :—

Staple food-grains.—Grain of some kind forms the principal article of food everywhere in India. The staple grains nearly all belong to the order of grasses (N.O., *Gramineæ*), often termed cereal grains. The staple grain of each place is that which is most largely cultivated and cheapest in the locality. Thus, in Southern India, *rice* is extensively cultivated and forms the staple food of large populations in the coast districts, along the course of the large rivers, and wherever else there is an abundant supply of water for irrigation; *ragi* forms the staple food in many places where the soil is moist, but not sufficiently so for rice; while, on

drier lands, some other kind of millet, such as *cholam* or kambu, forms the staple food. The cereal grains, which may fitly be called "primary foods," form the great bulk of the food of people of all religions and castes, rice being usually preferred by Brahmans and the wealthier classes.

It is mainly in the choice of secondary foods that religious and caste influences are noticeable.

The ratio of the nitrogenous to the carbonaceous constituents of some of the principal cereals is shown in the subjoined table :—

	Nitrogenous.	Carbonaceous.		Nitrogenous.	Carbonaceous.
Buck wheat	1	4·7	Maize (whole)	1	8·3
Wheat	1	5·2	Ragi	1	12·3
Amaranth	1	5·2	Rice (cleaned)	1	10·5

It is evident that cereals, such as ragi, rice and maize, do not contain sufficient nitrogen to allow them to be used as the sole food (*vide* ratio 1 : 6 on page 22). Cereals contain too small a proportion of proteids and of fat to form perfect foods, and they consequently require the addition of other food-stuffs which are rich in proteids and fat. Rice is particularly deficient in both respects, as well as in the proportion of mineral matter which it contains. Wheat contains a sufficiency of proteids and mineral matter, but not sufficient fat. The millets, which include most other food-grains, are inferior to wheat in the proportion of proteids which they contain, but superior to it in the proportion of fat. In India the millets, taken all together, are more important than either rice or wheat because they form the staple food of larger populations. The ash (mineral residue) of cereal grains consists largely of phosphoric acid and potash, which are two of the most valuable mineral ingredients of food. The following table

shows the percentage composition of the principal staple food-grains of India*:—

Grain (husked).	Proteid.	Starch.	Oil.	Ash.	Water.	Fibre.
Rice	6·5	79·1	0·6	0·6	12·8	0·4
Koda	7·0	77·2	2·1	1·3	11·7	0·7
Ragi	7·3	73·2	1·5	2·3	13·2	2·5
Gundli	9·1	69·0	3·6	3·5	10·2	4·6
Maize (big joar or cholam) ..	9·5	70·7	3·0	1·7	12·5	2·0
Great millet (small joar or cholam).	9·3	72·3	2·0	1·7	12·5	2·2
Bajra (kambu)	10·4	71·5	3·3	2·0	11·3	1·5
Italian millet (kangu tenai) ...	10·8	73·4	2·9	1·2	10·2	1·5
Varagu	12·6	69·4	3·6	1·4	12·0	1·0
Wheat	13·5	68·4	1·2	1·7	12·5	2·7
Amaranth	13·7	58·4	6·0	5·2	11·9	4·8

In the preparation of these grains for food, husking or removal of the outer coverings of the seeds is the first operation. This is commonly accomplished by beating the dry grain with a pestle and winnowing away the husk.

The method of cooking varies with different grains, and in different places, but there are four principal recognized methods: (1) the grain is boiled whole in a considerable quantity of water, which is strained off as soon as the grain is sufficiently cooked: it swells by absorbing water and about doubles in weight; the cunjee water is drunk separately, fresh, or after it has become acid by fermentation on keeping; (2) the grain is pounded or ground in a hand-mill, and the meal or flour thus

* This table is taken from Church's Food-grains of India, 1886 (from analyses by Forbes Watson and Church), but McNally's figure for albumenoids in rice has been substituted as more nearly representing the average composition of that grain. In analyses made by McNally of food samples of several food-grains obtained in Madras, the proportions of albumenoid were almost identical with those here given, except in the case of cholam, in which they were considerably, and in ragi, in which they were slightly, higher.

obtained (or sometimes the whole grain) is boiled with a moderate quantity of water, so as to form porridge, or with less water to form pudding; (3) the meal or flour is made into a thick paste with water and formed into cakes, which are baked in a pan; (4) the grain is parched by stirring it in hot sand and sifting it out. A mixture is often made of cholam, ragi, varagu, or other grains, or of ragi or millets with rice, especially for cooking in the form of porridge or pudding. In whatever way the grain be cooked it is eaten either hot or cold, along with salt and various condiments and with or without ghi or oil, dhal, meat, vegetables, sugar or other subsidiary articles of food.

Attention may here be usefully directed to a few practical points connected with these staple grains.

Rice is eaten by about one-fourth of the population in Southern India.* Eight parts of husked rice yield five of cleaned rice, and two parts of the latter, when boiled, yield five parts.† Rice should be kept for at least six months after it is harvested, because new rice is unwholesome, and apt to cause indigestion and diarrhœa. Partly boiled paddy keeps better and is probably more wholesome, though less white in colour, than raw table rice. New rice can be cooked in about half an hour, yields a thick cunjee water and does not keep well after cooking. Old rice takes about twice as long to cook, yields a thin cunjee water, and keeps good for more than 24 hours after cooking.‡ Rice owes its popularity as an article of diet to the digestibility of its starch grain. It should be cooked by steaming and not by boiling, as most of its proteids and salt are dissolved out by the water. If the cunjee

* More than 30 per cent. of the population of the Madras Presidency according to the Famine Commission.

too is used this does not so much matter. It forms a suitable habitual food if its deficiencies are made good by the addition of substances containing proteid and fat. Dhal or some other leguminous seed or animal food will supply the former, and milk, ghi and vegetable oils the latter.

Ragi is superior to rice in the proportion of proteid, oil, and especially of mineral matter, which it contains. In its proportion of proteid and oil it holds a position intermediate between rice and the other millets. If combined with a sufficiency of proteids and oily substances it forms an excellent staple food. It is, however, apt to disagree at first with persons unaccustomed to its use, and, as a rule, it is eaten only by the labouring classes. In parts of Mysore, Hyderabad, and many Madras districts it is much used. Ragi possesses the advantage of keeping good for an indefinite period, and it has been found perfectly preserved in grain pots which have been disinterred after having lain buried for more than a generation. Ragi is commonly eaten as porridge or pudding; but it is sometimes cooked in the following way. The ground grain is mixed with cold water and exposed to the sun for a day or two, until it becomes sour, when it is boiled and allowed to cool. It then forms a jelly with a pleasant acid flavour.

The other millets mentioned in the foregoing table are koda, gundli, joar (cholam), bajra (kambu), kangu, varagu. The composition of these grains varies a good deal in different samples, but (with the exception of koda, which is about equal to ragi) they may be taken as averaging about 10 per cent. of proteid, 3·5 per cent. of oil, and 71 per cent. of starch. Thus the ratio of proteid to carbonaceous constituent would be nearly 1 : 8, and of the oil to total carbonaceous as 1 : 9·5, so that a moderate addition of albuminous and oily substances is

required to render the millets perfect foods. They are certainly far superior to rice and but little inferior to wheat as staple food-grains.

Wheat is an important food in parts of the Punjab, United Provinces, Central Provinces and Bombay. In Madras it is not habitually eaten except by Europeans and some wealthy Muhammadans. It contains a sufficient proportion of proteid (1 : 5·3), but is too deficient in oil (1 : 25) to serve as a complete food.

Wheat is ordinarily prepared for food by being ground into flour, the flour being separated into *suji*, which is the finest and most starchy part, *maida* the medium, and *ata* the coarsest. The outer indigestible coats of the grain form the bran, which is rejected, but ata contains some of the finer inside coats, and is richer in proteid, oil and salts than suji or maida. The latter are used for making sweet-meats.

Ata is commonly made into a paste with water and fashioned into cakes (chapaties) which are baked at a moderate heat. Biscuits are wheaten cakes baked at a high temperature. Bread is a spongy form of wheaten cake, which is more easily digestible than the chapati, and is generally made by adding fermenting toddy, or yeast, to the paste (dough) formed by kneading flour and water. The bubbles of gas liberated during fermentation form little cavities in the bread and render it light and porous. One hundred parts by weight of flour should yield 136 parts of good bread.

Amaranth is the only staple grain here mentioned which does not belong to the order of grasses. The plant is generally cultivated in mountainous parts of the country and its seed often forms the principal food of the inhabitants of those regions. In the Deccan these seeds are eaten on

fast days by Hindus, and are usually parched and taken with sugar. The green leaves of amaranth are used as a vegetable. This grain is the most nutritious of all the grains here mentioned and alone contains a proper proportion of proteid and of oil.

Leguminous Grains.—Leguminous food-grains, often termed pulses, are the seeds of pod-bearing plants, such as the various kinds of dhal, gram, beans and peas, and form valuable and much-used food materials. They are principally remarkable for the large proportion of proteid which they contain and for their comparative indigestibility. For the former reason they are extremely useful in supplementing the deficiency of albuminates in cereal grains; but for the latter reason they can be eaten only in very limited quantity. Dhal, especially if not well cooked, is a frequent cause of diarrhœa and is often passed undigested by the bowels. It is particularly likely to disagree with persons unaccustomed to its use.*

The digestibility of these grains is promoted by admixture with easily digestible foods and by careful and prolonged cooking after being soaked or ground.

Besides being very rich in proteid, the pulses are rich in mineral matter (containing much phosphorus and sulphur), and, although they generally consist largely of starch, some of them contain much oil instead of starch.

The nitrogenous ratio in the case of the pulses varies from 1–2 or 4.

The quantity of pulse consumed daily by non-flesh eaters is usually 2 to 4 oz., and it is not

* Kasari dhal (*Lathyrus sativus*, vetchling) which is used in parts of North Western Provinces and Oudh, when habitually eaten in large quantity causes paralysis of the legs. Some kinds of *Phaseolus*, as *Phaseolus lunatus*, also appear occasionally to have poisonous properties.

advisable that the latter quantity should be much exceeded.

The following table gives the percentage composition of some of these grains :—

Name of pulse.	Proteid.	Starch.	Oil.	Ash.	Water.	Fibre.
Chick-pea (Bengal gram).	21·7	59·0	4·2	2·6	11·5	1·6
Mung gram	22·7	55·8	2·2	4·4	10·1	4·8
Pea	23·6	57·5	1·5	2·5	11·8	1·0
Lentil	24·9	59·5	1·3	2·2	11·8	1·2
Ground-nut	24·5	11·7	50·0	1·8	7·5	4·5
Soy bean	35·3	26·0	18·9	4·6	11·0	5·2

The pulses are prepared for food in various ways: (1) the grain is soaked in water until it swells (for 24 hours or less), or, even without soaking, it is husked and boiled with condiments and eaten, generally with the addition of vegetables, as a curry, along with the staple food; (2) it is ground, mixed with condiment and made into cakes or small balls, which are often fried in oil or ghi, and also eaten with staple food; (3) it is parched, in the same way as rice and other grains, and thus is often used as food by labourers and travellers.

The green pods and young leaves of many leguminous plants are valuable and largely used as vegetables.

The number of leguminous grains which are used as food is considerable, and the above table gives analyses of only a few typical examples. Mung gram may be taken as an average representative of the various kinds of gram and dhal in ordinary use. Pulses rarely contain less than 20 per cent. of proteid, peas sometimes contain 28 per cent. and soy beans more than 35 per cent. A good Madras sample of Tur dhal, analysed by McNally, contained over 25 per cent.

The ground-nut is remarkable for the quantity of oil which it contains. It is commonly prepared as food by being roasted and husked.

The soy bean is largely used in China and is cultivated in India and Upper Burma. It is the best of all pulses for supplementing the deficiencies of rice and other starchy cereals because of its great richness in proteid, oil and mineral matter.

Animal Foods.—Animal albuminous foods are the most easily digestible and, in most countries, the most extensively used of substances rich in albuminous material. The flesh of various animals, including fish, is eaten by Europeans, Muhammadans, and the majority of Hindus when they can get it. Flesh-eating Hindus are by their religion precluded from eating beef; while for the same reason, Muhammadans may not eat pork. Brahmans and other caste Hindus, who may not eat any flesh, are, however, very partial to milk in its natural state, or in the form of curds (tyre) or butter-milk and ghi, as an article of diet, and many so-called vegetarians eat eggs. The percentage composition of the most important animal albuminous foods is shown in the following table :—

—	Proteid.	Oil.	Sugar.	Water.	Salt.
Lean meat	18·3	4·9	...	72·0	4·8
Fish	16·0	5·0	.	78·0	1·0
Eggs	14·0	10·5	...	74·0	1·5
Milk	4·8	3·3	4·2	87·0	0·8
Blood	21·2	0·3	...	77·9	0·6

In the above analyses the meat is without bone or fat and the eggs are without shell.

Dried fish and *dried meat*, weight for weight, contain nearly 50 per cent. more proteid constituents than the same articles when fresh.

Meat is commonly prepared for food by being cut into pieces about an inch in diameter, which are (1) mixed with curry stuff and fried in fat, oil, or ghi; (2) spitted together, smeared with condiments and fried or roasted as kabab; (3) boiled or stewed along with vegetable curry. Europeans generally roast or boil meat in large pieces. Meat loses about 20 per cent. in weight by boiling and 30 per cent. by roasting. The proportion of bone and fat in meat varies much with the kind and condition of the animal and in different parts of the same animal. In average Indian mutton bone forms about 25 per cent. of the whole carcase and fat less than 15 per cent.

Fish is generally a wholesome and nutritious food, being nearly equal in value to lean meat. Fish, whether fresh, salted or dried, is a favourite ingredient of curries. It is deficient in mineral constituents.

Salted and dried fish, though in itself wholesome if the processes have been properly performed, is without doubt responsible for a vast amount of intestinal derangement and sometimes death among the poorer classes, since much of the salt-fish that finds its way into the hands of the consumer has been only half cured and is eaten in a state of decomposition.

Some kinds of fish* are always, and others are occasionally poisonous. *Crustacea* such as prawns,

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* Intestinal irritation and collapse and sometimes delirium are caused by poisonous fish. The poisonous nature of the globe fish is well known, and the occasional poisonous effect of oysters. Dr. Day mentions a barbel and a carp found in Himalayan streams which are poisonous. The Indian mackerel (Scomber) and sardine (Clupea), both abundant on the Malabar coast, are sometimes poisonous, especially when beginning to decay. Fish may become more or less poisonous from being kept in very foul tanks.

and *mollusca*, such as oysters, resemble fish in nutritive value but contain less oil.

Eggs of the common fowl, or of other birds, form a completely digestible food, which is, weight for weight, nearly equal to lean meat in proteid and superior to it in fat. Eggs are often eaten hard boiled and cut up in curries; but they are more easily digested if the white and yolk be mixed together and boiled (poached) or fried in ghi or oil to form an omelette which may be cut up and curried. Eggs differ a good deal in size; an average Indian hen-egg (deducting shell) weighs about $1\frac{1}{4}$ ounce.

Milk is an important food in all countries, but in India it is especially so, as it forms the sole animal food of Brahmans and some other classes, and is more or less partaken of by all. The quantity of milk yielded by cows varies considerably with the breed and food of the cow and the age of her calf; Indian cows do not often yield more than $4\frac{1}{2}$ pints in a day. This is about a quarter of the yield of a good English cow, and the chief reason for the small quantity and bad quality of the milk of the Indian cow is the want of proper nourishment. The cow owner expects the cow to give everything and to receive practically nothing. Admitting that fodder is sometimes scarce it is a fact that, even in times of plenty, cows in towns are habitually underfed. The composition of cow's milk is tolerably uniform except with regard to cream (oil) which varies considerably (1·9 to 4 per cent. or more). Milk is rarely taken raw, except by Europeans; boiled milk is preferable, because it keeps better and any germs which may be present are destroyed by boiling. The milk of animals for some days after calving is of a very oily nature and likely to cause diarrhœa.

Tyre is milk boiled down, some water being thus evaporated, and coagulated by the addition of an acid (which causes the casein to solidify). It may be reckoned as a little superior to ordinary milk in nutritive value.

Cream consists largely of the fat of milk together with a little proteid and sugar. On standing milk in a cool place about 60 per cent. of the fat rises to the surface and can be skimmed off. The skimmed milk which remains is still a valuable food as it contains most of the nitrogenous matter and sugar originally present in the whole milk. Of late years centrifugal machines have been largely used for mechanically separating the cream, and by this agency 90 per cent. of the fat can be readily extracted in a short time, the remaining liquid being of course much poorer than skimmed milk.

Butter.—When milk is churned or violently agitated by mechanical means, the globules of oil are induced to coalesce and a solid mass of milk fat, mixed with a variable quantity of milk, proteid and water, is obtained. An easier way of making butter is to take the cream obtained either by skimming or separating the milk and to churn that. Butter varies in appearance and taste according to the milk from which it is derived. Buffalo milk being the richest in fat gives the largest percentage of butter, but it is not so palatable as cow butter.

Buffalo butter is white and greasy and almost tasteless. To make it more pleasing to the eye and more closely resembling the best cow butter it is frequently tinted with an innocuous yellowish colouring matter called annatto.

Cow butter is faintly yellow in colour (the colour depends largely on the breed and feeding of the cow), firm and delicately flavoured. Both milk and the butter derived from it can be greatly altered in

taste and rendered quite unpalatable by injudicious feeding of the cow, such as the administration of rancid oil cake.

Buttermilk is the liquid remaining after the removal of the butter. It resembles skim milk in composition, but contains less fat and is slightly acid.

Ghi is made by heating butter until the water is evaporated and the casein which falls to the bottom of the vessel is slightly charred. The clear and sweet smelling residue is fluid at ordinary temperature, but becomes semi-solid during cold weather. The quantity of ghi obtained is much less than that of the butter used, and it is consequently much more expensive, so much so that pure ghi is scarcely obtainable in large towns, except to order. It is the chief source of fat in the diet of the vegetable eating Hindu.

Buffalo ghi is whiter than cow ghi and contains a higher percentage of volatile fatty acids.

Much of the ghi sold has not been heated so as to drive off the water and this preparation lacks the keeping qualities of the pure article. Pure ghi is said to be much improved in flavour by being stored in closed vessels for long periods, and specimens stated to be one hundred years old are not unheard of in the Madras Presidency.

Ordinary ghi is prepared from buffalo milk. The milkmen churn fresh buffalo milk with a rapidly rotating bamboo contrivance and remove the butter formed, which they subsequently turn into ghi, frequently adding some adulterant in the shape of vegetable or animal oil. The fluid which remains is sold as pure milk!

Blood is a very valuable and easily digested food, which is often partly or wholly wasted when animals are slaughtered. It is the practice to

drain off as much blood as possible from a carcase, but it ought all to be carefully saved. It may be cooked by being mixed with condiments and fried in ghi or oil, or it may be mixed with milk or with eggs or with the flour of any grain and be fried or otherwise cooked.

Oily Foods.—Oils may be divided into animal and vegetable, the former being the more readily digestible. Solid animal oils are commonly termed fats. Ghi is the most familiar example of an animal oil in this country. Fat is found in all animals on the inside of the loins and under the skin, as well as in other parts. The liver of fish contains a large amount of oil. Pork contains much more fat than any other kind of meat.

Vegetable oils are expressed from various seeds : ground-nut, cocoanut and gingelly oils, and kokam butter are the vegetable oils most used as food. Ghi and melted purified fat consist entirely of oil. Butter contains about 81 per cent. of oil, 4 of casein, 2·5 of salt and 12·5 of water. Crude fat is very similar in value.

Starches and Sugars.—The principal starches are the different kinds of arrowroot, obtained from several plants, and sago, from the pith of certain palm trees. They consist of starch with about 17 per cent. of water and are almost entirely digestible. Potatoes and yams contain about 20 per cent. of starch.

Sugar of the refined and crystallized kind, produced from the juice of the sugar-cane, is used only by the wealthier classes. It contains about 5 per cent. of water. Jaggery, which is commonly used, is a less pure sugar, obtained by boiling down the juice (toddy) of some palm-trees, especially the palmyra and bastard date. In Europe a great deal of sugar is now extracted from

beetroot and goes by the name of beet-sugar, and in America from the sap of the sugar maple.

Vegetables and Fruits.—Vegetables and fruits are of much importance in diet, their special value depending not so much on the amount of nutriment as upon the vegetable acids and salts which they contain and which render them necessary ingredients of a perfect diet. Persons who are deprived of vegetables or fruit, especially if they have been previously accustomed to them, suffer from a diseased condition termed scurvy. Vegetables are nearly always eaten cooked, and fruits raw, some fruits being used either as fruit or as vegetable.

Vegetables are ordinarily cooked by being (1) boiled with condiments as mulligatawny, (2) used as dry curry boiled and smeared with curry stuff, or (3) fried in ghi or oil and mixed with curry stuff as ordinary curry.

Vegetables and fruits may be divided into four classes (1) starchy and saccharine, (2) green, (3) watery and (4) condimentary, all classes being valuable antiscorbutics.

The starchy and saccharine vegetables are usually tuberous or fleshy roots, such as the potato, yam, carrot, onion and radish. These, and fruits of kindred nature such as the plantain and custard apple, are of considerable value as foods. The sugar-cane though not a fruit proper, may, for diet purposes, be classed with these fruits.

Some green vegetables are also useful nutritives, such as the pods of many leguminous plants, brinjal, and bandakai. Cabbage and greens of various kinds are less nutritive and are useful mainly as antiscorbutics. Watery fruits and vegetables, as the various kinds of cucumber, pumpkin and melon, the jack, mango, orange and grape, are good and pleasant antiscorbutics.

Condimentary fruits and vegetables are also useful for the same reason, but are principally employed for flavouring other food. Such are tamarinds, limes, turmeric, and aromatic leaves, fruits, and seeds of various kinds as capsicum, coriander, pepper, omum, &c.

Nuts, such as cashew-nuts, almonds, and walnuts are not very common articles of food, except cocoanut which is generally used as a condiment in curries; but they are rich in proteid and in oil, and consequently very valuable as food. They are, however, apt to disagree with those unaccustomed to them and they are indigestible unless well masticated.

Fruits and vegetables, wholesome in themselves, often cause indigestion and diarrhœa, because they are eaten in excessive quantity, or are unripe or overripe or stale; but they are sometimes unwholesome, owing to the possession of more or less poisonous properties, for instance wild varieties of the cucumber order.

Beverages.

A consideration of foods would be incomplete without some notice of alcholic and other liquids which are commonly used as drink. Water, the only essential beverage, is so important that it is treated of in a separate chapter. Other beverages may be classed as: (1) sherbets, (2) alkaloidal drinks, (3) fermented liquors, (4) distilled liquors.

Sherbets are made from the juices of various fruits, such as the lime, orange, grape, or pomegranate, mixed with water, and sometimes with sugar and aromatics added. They are pleasant and wholesome drinks, valuable as antiscorbutics. Cunjee-water and pepperwater may be classed with these beverages.

Tea and *coffee* are the principal alkaloidal drinks, so called because their active constituent is a substance belonging to the class of alkaloids. Tea also contains tannin, to which dyspepsia and constipation are occasionally due if the tea be too strong or too long infused, and coffee contains some oil. These drinks are of no value as nutrients, but they are mild non-intoxicating stimulants. Like other warm drinks their mere warmth has a certain stimulating effect. The effect of both tea and coffee is usually tonic and beneficial, but, if used to excess or in peculiarly excitable temperaments, they may be prejudicial and lead to undue nervous excitement and sleeplessness.

Fermented liquors are produced by the fermentation of sugar or starchy substances mixed with water. *Toddy* and *beer* are the most important of these liquors. Toddy is the juice of various palms, principally the palmyra, bastard date, and cocoanut. The juice as it flows from the tree consists of water, containing a considerable quantity of sugar and a little albuminous matter in solution ; but it soon begins to ferment as the result of the multiplication of a yeast fungus in the liquid, its sugar being converted into alcohol and carbon dioxide gas ; the latter is the cause of the frothing up of fermenting toddy. The fermentation is complete usually within 24 hours. Cocoanut toddy ferments most rapidly and contains most alcohol, date toddy comes next. Toddy contains about 5 per cent. alcohol and is similar to a light beer in its effects.

Beer is obtained by fermenting malted grain, usually barley or rice, or grain prepared by being strongly heated by steam. Both beer and toddy contain a small quantity of sugar and albuminous substance, which, besides their alcohol, give them some little value as food.

Distilled liquors are obtained by distilling the alcohol (mixed with water) from fermented mixtures of sugar or starchy substances. The peculiar flavours and odours of different kinds of spirit depend upon the presence of minute quantities of various essences derived from the substances used, but alcohol is the principal ingredient of all. Toddy, jaggery, the refuse of sugar factories, mhowa flowers, and grain are the principal substances from which distilled liquors are obtained in this country.*

The strength of ordinary arrack is about 40 per cent. of pure alcohol by volume (30° under-proof).

Regarded as an article of diet there can be no doubt that alcohol in no form or shape is a necessity under any climatic conditions. In healthy persons, taken in moderate quantities not exceeding 1 to 1½ oz. of absolute alcohol daily, it seems impossible to prove that it has any injurious effect, though, on the other hand, it cannot be maintained that it has any particular beneficial action beyond a temporary feeling of well-being.

Abuse of alcohol leads not only to derangements of the functions of the body which may result in the death of the individual, but also, when widespread in a race, to social disorganization. On the whole, as now used by mankind at large, alcohol is productive of far more harm than benefit.

Rations and Dietaries.

If the principles and facts already laid down be borne in mind there will be little difficulty in constructing rations suitable for any given circumstances or in detecting any deficiencies of existing rations; but this subject is one regarding which

* Cashew nut fruit is used on the Malabar Coast, and sorghum cane and prickly pear fruit have been used in other places.

ignorance has so often resulted in widespread mortality that, even with some repetition, a separate section is here devoted to it.

The question of diet is so frequently connected with that of disease and mortality, that in any case where excessive sickness and mortality—especially if due to bowel disease, scurvy or anæmia—is found to prevail among a population or in bodies of troops, or in jails or hospitals, the first suspicion of an experienced sanitary investigator is directed to diet.

The constitution of one ounce of each of the principal food substances is shown in the following table in fractions of an ounce. It may be observed that this table is merely a repetition of the separate tables already given, with the decimal points of the numbers moved two places to the left so as to indicate fractions of unity instead of percentages. It will, however, be found of great utility in facilitating the construction of dietaries to have all the figures in one conspectus :—

Table for calculating diets.

Food stuffs.	Proteid.	Starch or sugar.	Oil.	Mineral.	Fibre.	Water.
Cereal Grains.						
Rice ...	0·065	0·791	0·006	0·006	0·014	0·128
Koda ...	0·070	0·712	0·021	0·013	0·007	0·117
Ragi ...	0·073	0·732	0·015	0·023	0·025	0·132
Gundli ...	0·091	0·690	0·036	0·035	0·046	0·102
Maize (big joar).	0·095	0·707	0·036	0·017	0·020	0·125
Small joar (great millet) ...	0·093	0·723	0·020	0·017	0·022	0·125
Bajra (kambu) ...	0·104	0·715	0·033	0·020	0·015	0·113
Kangu (tenai) .	0·108	0·734	0·029	0·012	0·015	0·102
Varagu ...	0·126	0·694	0·036	0·014	0·010	0·120
Wheat ...	0·135	0·684	0·012	0·017	0·027	0·125
Amaranth ...	0·137	0·584	0·060	0·052	0·048	0·119

Table for calculating diets—cont.

Food stuffs.	Proteid.	Starch or sugar.	Oil.	Mineral.	Fibre.	Water.
Leguminous Grains.						
Chick pea ...	0·217	0·590	0·042	0·026	0·016	0·115
Mung gram ...	0·227	0·558	0·022	0·044	0·048	0·101
Pea	0·236	0·575	0·015	0·025	0·010	0·118
Lentil ...	0·249	0·595	0·013	0·022	0·012	0·118
Ground-nut ...	0.245	0·117	0·500	0·018	0·045	0·075
Soy beam ..	0·353	0·260	0·189	0·046	0·042	0·110
Animal Food.						
Lean meat ...	0·183	...	0·049	0·048	...	0·720
Fish ...	0·160	...	0·050	0·010	...	0·780
Eggs ...	0·140	...	0·105	0·015	...	0·740
Milk ...	0·048	0·042	0·033	0·008	...	0·870
Blood ...	0·212	...	0·003	0·006	..	0·779
Starches and Sugars.						
Arrow-root ...	...	0·83	...	..	...	0·17
Sugar ...	...	0·945	...	0·005	...	0·050
Oils and Fats.						
Butter ...	0·040	...	0·810	0·025	...	0·125
Ghi and oil ...	...	...	1·000	...	.	...
Vegetables and Fruits.						
Starchy and Saccharine (potato or plantain) ...	0·025	0·211	0·001	0·013	0·010	0·740
Green and watery (cabbage) ...	0·002	0·058	0·005	0·007	0·018	0·910

Any ordinary rations can be easily and quickly reduced to their alimentary constituents by means of the above table: all that need be done is to multiply the quantity in ounces of each food-stuff contained in the ration by the numbers given opposite it in the table in order to obtain the quantity in ounces of its alimentary constituents. For example, the lowest Famine Code diet consists of 2 oz. of dhal and 20 oz. of cereal grain. If we

suppose Bengal gram (chick-pea) and cholam (joar) to be used, we multiply each of the numbers opposite chick-pea in the table by 2 to obtain the quantities of proteid, etc., in 2 oz. of it, and similarly we multiply the numbers opposite joar by 20 to obtain the quantities in 20 oz. of it. This gives:

—	Proteid.	Starch.	Oil.	Mineral.
2 oz. Bengal gram ...	0·434	1·180	0·084	0·052
20 oz. cholam	1·860	14·460	0·400	0·340
Total value of ration ...	2·294	15·640	0·484	0·392

Now to ascertain the ratio of nitrogenous (proteid) to carbonaceous constituent in this ration we obtain the starch equivalent of the oil by multiplying the latter by 2·4 ($0·484 \times 2·4 = 1·16$); this being added to the amount of starch gives 16·8 as the total weight of carbonaceous constituents, reckoned as starch. Dividing the weight of proteid into this $\left(\frac{16·8}{2·294}\right)$ gives 7·2; the proportion of nitrogenous to carbonaceous constituent in this diet is therefore 1 : 7·2, which is too low. The starch equivalent of the oil we have seen is 1·16 and the proportion $\left(\frac{16·8}{1·16}\right)$ which it bears to the total carbonaceous constituents is 1 : 14·5, this also being much too low. This ration is therefore very (though perhaps unavoidably) imperfect as it stands. Its defects might be corrected by (1) the addition of a little animal food rich in oil, or (2) of seeds rich in proteid and oil, such as ground-nuts or soy beans, or (3) by increasing the proportion of gram to cereal grain and adding the requisite amount of oil separately. Nearly ½ oz. of salt and some fresh vegetables would also be required.

In constructing rations for any given individual or group, the simplest plan is, in the first place,

to determine the proportions of constituents and the absolute quantity of food required according to the circumstances of the case; secondly, to take a quantity of the staple food-stuff equal to the amount of food required; and, thirdly, having reduced this to its constituents, to substitute for a part of it such portions of available secondary foods as may be needful to give the proper ratios of constituents.

Cases sometimes occur in which only a few food-stuffs are available—possibly only one; and in such cases it may be impossible to apportion the constituents in due ratio. The only principle which can then be observed is to make sure that the food shall contain at least a sufficiency of proteid nutriment, even if other constituents have to be in great excess.

It has happened in jails, and probably it frequently happens amongst the cooly classes also, that the nature of the food-stuffs eaten is such that although a sufficiency of proteid is consumed, it is in a form which cannot be easily assimilated. As much as 30 per cent. of the intake of proteid may thus escape digestion, and either leave the body as waste in the excreta or decompose in the intestine and set up a catarrhal condition with diarrhœa followed by emaciation. A sufficient quantity of proteid may fail to be digested owing to its being lost as it were in an excessive bulk of carbohydrate. A diet to be nutritive must be so constructed that none of its elements is in excess and that all are present in a digestible assimilable form. The question of expense is usually an important one in the formation of dietaries, and one which has to be carefully considered; it cannot here be entered into further than to state that it usually resolves itself into the substitution of the cheaper for the more expensive secondary foods and the limitation of variety in diet.

To sum up, all the points which require attention when constructing dietaries are: available food materials, their composition and their cost; amount of food required, having regard to body, weight, age, work, habit, climate; proportions of alimentary constituents required, having regard to the same considerations; provision of fresh vegetable or fruit; provision of salt; variety; cookery; digestibility; allowance for waste; division of ration and hours of meals; arrangement of rations for group of individuals. Sufficient has already been said regarding some of these points; those which have not been, or have been but partly discussed must now receive attention.

Fresh vegetables and fruits are necessary, in all good dietaries, to prevent scurvy. They are also useful in giving variety of flavour and consistence to the staple articles of food and in promoting regular action of the bowels. If ordinary vegetables cannot be obtained, the leaves of any non-poisonous plants may be eaten as substitutes. Lime-juice is a good antiscorbutic; it is usually preserved by the addition of some spirit and is always carried in ships when fresh vegetables are not available. Dried or tinned fruits and vegetables may also be used with advantage when fresh are not procurable. Four to eight ounces per day is a moderate allowance of vegetables or fruit, though less may suffice for preservation of health. Unless vegetables or fruit are used in larger quantities than this their diet value may be disregarded in calculating rations.

The quantity of *common salt* to be added to a ration will depend upon the nature as well as the absolute amount of the food materials; for instance, salt fish or meat may require no such addition, while cereal grains and vegetables require most. Enough should always be used to make up, along

with the *ash* in the food-stuffs, a sufficient amount of mineral food. The necessary quantity rarely exceeds half an ounce.

Other mineral salts are necessary, especially phosphates of potassium and calcium, and their place cannot be taken by common salt. It is, therefore, improper to supply the mineral deficiencies of such food-stuffs as rice or sago by the addition of common salt only. When rice, or other food deficient in mineral matter, is the staple, it would be very desirable to adopt a practice which is said to be followed by some rice-eaters in Bengal, who use the ashes of gram plants along with their food. Any kind of gram or bean plant is well suited for the purpose, as such plants contain a large proportion of phosphoric acid. Habitual rice-eaters should employ the ashes of these plants, or of other green plants, mixed in the proportion of at least one-third with the common salt which they use as a condiment.

Variety in diet is an important consideration. Even when only one principal staple food is eaten, great variety of consistence may be obtained by different modes of cooking it, and variety of flavour by the use of various secondary foods and condiments. Thus even the poorest usually obtain considerable variety in their food. Indigestion and malnutrition are apt to result from a monotonous diet; and, in arranging dietaries, it should always be a practice to vary the food as much as possible. As a rule, it is not difficult to make some change for every day in a week.

Cookery is another subject which should engage attention. Good food is often rendered distasteful by bad cookery, while indifferent food is often made palatable by good cookery. Palatability is a very important matter; it is a familiar fact that savoury

and well-cooked food "makes the mouth water," that is, it excites the flow of saliva and probably at the same time of gastric secretions, and therefore such food is readily digested as well as agreeable to eat. On the other hand unsavoury and ill-cooked food is apt to excite disgust, nausea and indigestion, or it may even be rejected by the stomach. Cookery is, to a great extent, a matter of taste and of habit, and varies among different races and classes; therefore, no very precise general rules regarding it can be laid down, except that it is better that most food substances should be too much rather than too little cooked. In imperfectly cooked joints of meat and loaves of bread the temperature in the centre of the mass is not sufficiently raised to destroy all organisms. Cooking, if thorough, will destroy all parasites in meat and also all bacteria, but not necessarily the poisonous products of the latter, so tainted meat cannot always be deprived of its power for harm and rendered safe to eat by cooking. During the process all albuminous substances are coagulated and connective tissues gelatinised, the cellulose coverings of starch granules are burst, thus allowing the digestive fluids to have access to the soluble interior of the grain, and the starch is partially converted into dextrin. Cooking is an art to which far too little attention is paid in most countries. There is a sort of notion that every woman can cook by instinct and that every man can prepare a meal if really put to it. The truth is that the theory and practice of cookery requires as close study and as much experience as most other arts, that no one can cook well without an intelligent appreciation of the reasons underlying the various acts performed, and that to neglect to acquire the accumulated knowledge of generations in the art of cookery before making a start, is likely to lead to as poor results as might be expected from

a person who without previous instruction sets up in a trade which necessitates much technical knowledge and manipulative skill.

The Madrassi has won some renown in cookery, but his genius lies more in the direction of preparing a palatable though innutritious meal out of unpromising substances than in doing credit to really good materials.

Times without number soldiers in the field have been half starved and rendered ill and inefficient by their inability to make the raw and perhaps coarse food materials supplied to them palatable and digestible. The poor of almost every race suffer through similar ignorance, and waste in an incredible fashion really nutritive substances.

Regarding *digestibility*, it should be noted that a fair proportion of indigestible material is desirable in food, in order that absorption of nutritive materials and intestinal action may be promoted by its bulkiness. A diet which consists almost wholly of digestible materials is apt to produce constipation and possibly contraction of the alimentary canal. Unusual or badly-cooked articles of diet, though nutritious in themselves, may, on the other hand, prove to be too indigestible.

Some allowance must always be made for *waste* in preparing food and for a portion of it which remains undigested. Five per cent. excess of alimentary constituents may be allowed on this account, or the nutritive value of the vegetables in the diet should not be reckoned. From 5 to 10 per cent. of ordinary food-stuffs is indigestible and forms the bulk of the excreta. The proportion is highest in the case of vegetable feeders who ingest a considerable quantity of cellulose which the digestive juices of man are unable to dissolve.

The *hours* and *number of meals* in a day and the division of the food between them are, to a great extent, matters of habit. Young children should have food at more frequent intervals than adults. Three meals a day is the usual number for adults in India (and in most other countries). A working man will ordinarily eat a light breakfast at 6 A.M., say $\frac{3}{4}$ lb. of porridge with salt and condiments and conjee water or perhaps butter-milk or a little tyre; at 1 P.M. dinner, a similar meal with possibly a little curry; and at 8 P.M., supper, the principal meal of the day, consisting of about $1\frac{1}{2}$ lb. of porridge, pudding, or oil and fresh vegetables or gram or dhal, and occasionally fish or other meat.

Rations for large numbers.—The construction of rations for single individuals or for families is not a difficult matter, but when large numbers of people, differing in weight, if not in age and habits, have to be fed, the subject becomes much more complex. We have seen that young children require a proportion of alimentary constituents and an absolute quantity of food relative to weight different from what is needed by adults. It is always necessary therefore to provide a separate diet for young children. Those over fourteen years of age may be treated as adults. With regard to the apportionment of diet according to weight, in an assemblage of adults, it is a prevalent practice to regulate the diet on the basis of the *average* weight of all the individuals. It follows that those who are above the average weight receive too little, while those who are below it receive too much food: in other words, about one-half of the people are under-fed and the other half over-fed. This method is therefore obviously not correct. If all the individuals of a group are to be sufficiently fed, the diet must be calculated for the weight of the *heaviest*. Thus considerable waste, or over-feeding

of the majority, cannot be avoided in laying down a sufficient uniform ration for a large number of individuals. The waste or over-feeding may, however, be reduced to small limits by dividing the persons into classes according to weight, and giving a ration to each class based upon the greatest weight in that class. In weighing individuals for this purpose, excessive fat should not be reckoned, and judgment must be used in relegating adipose individuals to a lower class than their mere weight would accord them.

Finally, it may be stated that absolute accuracy is practically unattainable in constructing dietaries; but a near approximation to requirements can nearly always be made, and it should be a rule to err by excess rather than by deficiency.

Preservation of Food.

In this connection the main fact to be remembered is that decomposition does not occur in the absence of bacteria. For their multiplication, moisture and warmth are necessary. Hence foodstuffs may be preserved by the destruction and subsequent exclusion of bacteria, by the addition of substances inimical to their growth, by desiccation and by cold. The first method is illustrated by tinned foods. The substance to be preserved is sealed up in a tin, only a tiny hole being left open; it is then sterilised by heat, and while still hot, the small hole is soldered up. All organisms within the tin having been destroyed by the heat, and no others being able to enter, the contents will keep good indefinitely. The second method includes preservation by the addition of salt, sugar, oil, vinegar and certain chemicals. Fish and meat are preserved by salting and drying, and any food can be preserved by keeping it at a low temperature, below or near

the freezing point of water. Bacterial growth is then inhibited and decomposition cannot occur, though most of the organisms present are not actually killed by the cold, but can multiply and decompose the food as soon as the temperature rises above about 10°C.

Preserved food is never quite as wholesome as fresh food and its use should be avoided when good fresh food can be obtained, not only on this account but also because the preservative process is not always carried out with due care, with the result that decomposition occasionally occurs subsequently. The destruction of all organisms on and in food by heat, and their subsequent exclusion by sealing up the food in a tin is the only preservative method which is permanent and at the same time innocuous. The use of chemicals as preservative agents is nearly always injurious to the consumer. Refrigeration, as a temporary means of preservation, has a future before it in India, and the time will doubtless come when capacious refrigerating stations will be established at the ports and in large towns, in which meat, milk, fruit and a variety of eatables can be stored until wanted. Refrigerating cars can also be attached to trains in which perishable goods can be transported from the areas of production to the large centres of consumption.

Concentrated Foods.—Food-stuffs cannot be concentrated beyond a certain degree. A lump of pure animal fat cannot be reduced in bulk, nor can a pound of pure carbohydrate such as starch or sugar be pressed or boiled into half a pound. Proteid matter alone by the evaporation of its contained water can be lessened in volume. Fluids such as milk can be made to occupy less space by the removal of water, without loss of nutritive substances. Most of the so-called extracts of meat

now on the market, far from being of higher nutritive value than the meat from which they are derived, contain very little proteid matter; their value lies in the stimulating properties of the salts and extractives of meat which they hold. Meat juices on the other hand contain a considerable percentage of proteid in a fluid state.

The various forms of "emergency ration" prepared for the use of travellers and soldiers on active service are not entirely satisfactory, and, though they fill a gap on occasion, the proportions of their constituents do not permit them to be used for long without digestive disturbances following.

Unwholesome Food.

Articles of food, wholesome and nutritious in themselves, may be unwholesome for those who are unaccustomed to them, and, at first, cause indigestion and diarrhœa. Thus wheaten cakes or dhal often disagree with those who are not used to them. Again, individual peculiarities occasionally occur: there are persons who cannot eat certain ordinarily wholesome substances, such as milk or fish, without suffering from colic or from nettle-rash.

The poisonous nature of some fishes and some leguminous grains has already been alluded to. It is probable that the flesh and milk of animals fed on garbage are also unwholesome.

Wholesome food may become unwholesome, or even actively poisonous, by decomposition. Thus mouldy grain or other food, vegetables or fruits, and more especially animal foods, including milk, which have begun to decay are dangerous to eat*.

* Not only men but other animals may be poisoned by mouldy food. Sir A. Cameron has published cases of both.

Instances of fatal poisoning by such articles of food are frequently met with. It is a common practice among the poorer classes in order to save the expense of a fire, to eat at breakfast, and perhaps also at midday, food which has been cooked on the previous day. Moist substances such as boiled grain, porridge, tyre and conjee-water may become unwholesome when thus kept, and communicable diseases may be propagated by them. Whenever food has to be so retained, it should be covered over and placed in a dry and clean place.

Uncooked or insufficiently cooked food is sometimes dangerously unwholesome. For instance, under-cooked dhal and grain of all kinds are very indigestible. Sweetmeats containing raw rice ought not to be eaten. The consumption of raw grain in large quantity may even cause death.

Foods preserved in tins occasionally become poisonous, though rarely to a grave extent, from the presence of lead or tin. Copper, derived from the still, is commonly found in arrack, occasionally in injurious amount. Copper poisoning not unfrequently results from cooking acid substances in copper utensils. Lead poisoning occurs occasionally owing to cooking pots being coated with that metal instead of tin. Lead poisoning has occurred in England among persons who used wheaten flour which had been ground in a mill in which a lead elevator was employed. It is not advisable that either leaden or copper vessels should be used in the preparation of food. A serious epidemic of arsenic poisoning in the north of England in 1902 was traced to the use of impure substances containing arsenic in the manufacture of beer.

Some bacterial diseases of animals, such as anthrax, may be communicated to man by means of ill-cooked food, together with sundry intestinal parasites. Hence meat, if at all suspected, should

be very thoroughly cooked if it has to be used as food. Curiously enough it has happened on more than one occasion in Madras City, where the law regarding infectious diseases of animals is for various reasons practically in abeyance, that persons of the sweeper caste have, unbeknown to the sanitary authorities, intercepted the body of a horse dead from anthrax and conveyed it to their hutting ground, where with the aid of sundry caste fellows they have in one night skinned, cooked and devoured it all. Subsequent careful observation of the persons who participated in these orgies failed to detect any harmful result whatsoever.

Adulteration of Food.

Manufactured or prepared foods are often adulterated. Some substances used as adulterants are injurious to health, and some may be offensive on other grounds, but all must be condemned as fraudulent. Some of the most common adulterations may be mentioned.

Milk, butter-milk and tyre, are commonly adulterated with water—often very dirty water, which may convey the germs of disease. Flour, plantains, and other substances have been employed to thicken milk thus adulterated. What is sold as butter-milk often consists of little but water, and this is occasionally thickened with the juice of a plant (*Uraemia speciosa*).

Ghi is frequently adulterated with ground-nut and gingelly oils, and sometimes with animal oil. Some samples of ghi having been found adulterated with animal fat led to the passing of a special legal enactment in 1886,* and 37 out of 71 samples of

* Bengal Act III of 1886.

ghi examined in Calcutta were found to be adulterated. In Madras ground-nut oil appears to be the most common adulterant of ghi.

Butter is adulterated most commonly with water and with fat. As much as 25 per cent. of water can be mixed with butter, and about this amount was found by McNally in some samples supplied by a contractor to a public institution.

Grains and spices are nearly always purchased whole by the consumer in India, and are therefore not liable to adulteration, except with sand and dirt.

So-called foreign liquors are sometimes entirely factitious, and are made up with common arrack variously flavoured and coloured.

Inspection of Food.

An organized inspection is manifestly important to check the sale of unwholesome or adulterated articles and the spread of disease by means of food. A competent food-inspector must be familiar not only with the appearance, odour and other qualities of good food-stuffs, but he must know how to detect bad ones and be guided by definite principles in condemning any article as unfit for food. A food-inspector, or even a medical officer, cannot be expected to perform a chemical analysis of foods—suspected articles must therefore sometimes be forwarded to a competent analyst for regular examination—but medical officers are occasionally able to make a useful microscopic examination of certain articles and to apply some qualitative tests. The most noteworthy points regarding food inspection and the examination of ordinary food-stuffs are here to be noticed.

In the inspection of bazaars, markets, bake-houses, dairies, cattle pens and sheds, and slaughter-houses,

the general cleanliness, provision of a pure water-supply, proper drainage and ventilation, regular conservancy, absence of foul or badly-made drains, latrines, dung-hills, or other causes of contamination of air, water, or soil, absence of disease among milch cows and among animals intended for slaughter, absence of infectious diseases among sellers and preparers of food or their servants or families, finally, wholesomeness and purity of all articles of food exposed for sale, are the main points which should engage attention.

Grain of all kinds is liable to become mouldy, therefore more or less poisonous and unfit for food, if kept in a damp place. Mould may be recognized by discolouration of the grain, the alteration of colour being variable and depending on the kind of mould, by the presence of a peculiar musty odour, and, if the mouldiness be far advanced, by the adhesion of grains to one another in lumps. If the mouldiness be only beginning, spots of discolouration may be found on separate grains, or entire grains may be so affected. Mouldy grain should be condemned as food.

Grain which is stored in a damp place may sometimes germinate, or begin to grow, as evidenced by swelling of the seed and cracking or bursting of its outer envelopes, and- perhaps partial protrusion of the embryo plant. Such grain should also be condemned as food. In addition to the intestinal disorders set up by mouldy and damaged grain, there are four definite nervous diseases which are attributed to the consumption over long periods of certain grains under peculiar conditions. These are :—

Beri-beri	connected	with	rice.
Pellagra	,,	,,	maize.
Lathyrism	,,	,,	kesari dhal.
Ergotism	,,	,,	rye.

In the case of the latter alone has the causative agent been identified with certainty. It is a fungus which flourishes in the rye grain while the plant is still growing. The diseased grains are ground up with the healthy ones and, if eaten in sufficient quantity, give rise to the malady in the consumers known as ergotism. So far it has not been reported in India.

Beri-beri seems to be connected in some way with damaged rice, but whether it is due to a bacterium or a fungus or a toxin derived from fermentative changes in the grain is not known. It is not even certain that rice has any relation with the disease, though some well-managed experiments in jails and institutions in Burma and the Malay States seem to point in that direction.

It may be that the disease is entirely due to malnutrition, that is, to the consumption for prolonged periods of rice which has been deprived of its outer coatings and their contained salts, notably phosphates, by excessive cleaning and milling.

Pellagra is fairly common in Italy and in Lower Egypt where maize is largely eaten but not in Upper Egypt where millets are the staple grains. Cases have been reported in South Africa, America and India. Maize is almost certainly implicated, but the actual cause of pellagra has not been identified.

Dr. Sambon, lately working with the Pellagra Field Commission in Italy, states definitely on the contrary that maize is not causatively connected with pellagra and that the disease is a parasitic one conveyed by the biting fly (*Simulium reptans*).

Lathyrism is well known in parts of India where kesari dhal is freely mixed with other food-grains. Here again the cause of the disease has not been recognised. All these four diseases are characterised by symptoms of nervous origin and paralysis.

Weevils are very common in all stored grains. The adult insect bores a hole in a grain and lays an egg in it. The egg hatches and the larva lives inside the grain and feeds on it, becoming in time a pupa. The adult is developed from the pupa and leaves its temporary home to attack other grains. In this way the greater part of a store of grain may be destroyed in a few months. A close examination of a handful of infested grain will show the presence of powdery material mixed with it, and hollow seeds will be found which have been excavated by the insects. When the weevils are abundant there will be little difficulty in finding some of them. If a handful of the grain be thrown into water the hollow grains and weevils will float on the surface.

Grain which contains only a few weevils may be used at once, but if heavily infested by such insects it should be condemned.

The larvæ of some small moths are also found in grain.

An important point in a country where grains are the staple food is their proper storage. This is difficult enough in cool climates which do not favour the rapid development of destructive insects, fungi and fermentative organisms, but it is doubly troublesome in damp, hot climates. It is the poorer part of the population which principally suffers when grain is badly stored, for then much damaged stuff is put on sale at cheap rates and is eagerly bought by the classes who never get quite enough to eat, and it is the business of the Sanitary officer to protect them from unscrupulous dealers.

Grain stores should be built so that their contents are protected from damp, of materials that will not harbour rats and insects, and so as to allow the free circulation of air in their interiors. At

the same time it should be possible to seal them up in such a way that the whole building and contents can be efficiently disinfected at stated intervals with sulphur dioxide gas which will at least destroy the rats and weevils. Freedom from damp and the free circulation of air must be relied on to inhibit the growth of moulds.

All gunny bags used for the transport of grain should be disinfected before and after use ; similarly, the holds of grain ships should be disinfected immediately after the removal of a cargo.

Flour of wheat or other grains may be attacked by mould or insects in the same way as entire corn. Acari, minute arachnids, which can be easily seen with a lens, are not unfrequently found in flour, particularly if it is damp. They closely resemble the acari of scabies. The presence of acari generally indicates that the flour is beginning to decompose, and if in large numbers should lead to its condemnation.

Wheaten flour should be white and soft to the touch, not gritty. It should not have a yellowish colour, or a mouldy or acid smell or taste, or contain any lumps. Old, decomposing or mouldy flour makes bad bread, which does not rise well, is discoloured and tastes mouldy or acid. Wheaten flour is often adulterated with other and less expensive starches and with mineral matter. When kneaded into a dough with water it should be tenacious and stringy on account of the glutin contained in it. The presence of other starch adulterations can be recognized microscopically by an expert in the subject. Wheat flour will float on chloroform, but admixed mineral matter will sink to the bottom.

Bread may be made from many kinds of flour, but millet and especially wheat are the best. Wheaten bread owes its form to the substance glutin

which is present in wheat flour and gives it its tenacious character. Bread made from rice flour and other flours is less tenacious and more crumbly, and cannot be aerated in the same way. Bread is aerated or fermented by the yeast fungus in the toddy or other leaven used in its preparation. In addition to aerating the dough the yeast changes part of the starch into dextrin and maltose and converts the proteid matter into albumose. Hence fermented bread has some dietetic advantages over bread in which the aeration is effected by baking powders, which merely liberate carbon dioxide in its interstices or by carbon dioxide forced into the dough by pressure.

Bread may be heavy and indigestible from bad toddy or other leaven, from insufficient baking or from too much water having been used. Bread containing too much water soon becomes mouldy and unfit for food. Alum and copper sulphate are occasionally added to bread to improve its appearance when bad flour has been used in the manufacture. They are easily detected by appropriate tests.

Brown bread is considered somewhat more nutritious than white on account of the larger quantity of proteid matter which is introduced by retaining some of the husk of the grain in the flour. It is however less digestible.

The proportion of nitrogenous to carbonaceous matter in the two is as follows :—

White bread	1—6 or 7
Brown bread	1—4

In **vegetables** and **fruits,** discolouration and softening in patches or throughout are the well-known signs of decay, and all decaying vegetables and fruits should be rejected without hesitation. Overripe and unripe fruits should not, as a rule, be used as food.

Milk, butter-milk, and to a less degree tyre, are very liable to be adulterated with water. Flour or other substance may also be dishonestly added. Any sediment which is found in milk should be subjected to microscopic examination; it may consist of impurities in added water, or of flour of some grain (which can be identified by its starch granules), or of blood, etc., from a diseased cow. The presence of added water in any quantity may be determined most readily by obtaining the specific gravity of the milk by means of a special instrument (hydrometer), or a urinometer, such as may be found in every hospital and dispensary, will answer the purpose. The specific gravity of milk ranges from 1,035 down to 1,026; if below the latter figure the milk should be condemned as watered. The specific gravity of milk is increased by about 2, by skimming off the cream, and it is lowered by about 3, for every 10 per cent. of water added. In testing the purity of milk, it may therefore sometimes be desirable to determine the percentage of cream as well as the specific gravity. This may be done by using a long glass tube or jar, graduated into 50 equal parts, having filled it with the milk to the top mark. The cream which floats on the surface after four hours' standing should occupy at least 3 divisions (= 6 per cent.).

Besides being a perfect food for the child, and for the adult when reduced by disease, milk is also a perfect medium for the growth of most bacteria and fungi. Hence it is impossible to be too careful in preserving it from the access of all dirt and foul effluvia, and in seeing that the place of milking, udders of the cow, and hands of the milkers, are all, to begin with, scrupulously clean, and that all vessels used have been properly scalded. Secondly, bacteria take time to multiply, so milk should be used as soon as possible. Thirdly,

bacteria do not grow well at a low temperature, so if milk has to be kept, the coolest available place should be selected and the vessel should be covered.

The dangers of milk are not so much those derived from a diseased cow, such as tuberculosis (tubercle amongst cows is very uncommon in most parts of India) but those added to it afterwards. Vessels are frequently rinsed out in dirty water, and milkmen will habitually keep as much water, obtained from the handiest source, in the bottoms of their tins as they can without detection: they have even been seen to scoop up some sewage from an open drain to dilute their milk. Such tricks favour the spread of cholera, typhoid and diarrhœa. The supply of milk in India suffers greatly from the poverty of the cow-owner which will not permit him to start a dairy on approved principles. There is moreover a marked reluctance on the part of the natives to go into partnerships and to effect with united capitals what one alone could not attempt. This reluctance is at the bottom of the indifferent quality not only of milk but of almost every kind of food obtainable in India. Analyses show that the composition of milk in England and in India is much the same. Milk which does not come up to a minimum standard fixed by law renders the vendor in England liable to prosecution, and the same ought to be the case in India. Without adulteration it is quite possible for cow-keepers by judicious feeding of their animals to cause them to produce large quantities of very poor milk, and such persons should also come within the law. As a general rule the specific gravity of milk is higher in the hot weather than in the rains, but, allowing for all such natural variations, a minimum standard of composition can very well be fixed. In Calcutta the following minimum percentage standard has been accepted :—

	Cow milk.	Buffalo milk.
Water	88·5	83·5
Total solids	11·5	16·5
Solids not fat ...	8·5	10·5
Fat	3·0	6·0
Ash	0·7	0·7

No person who is suffering, or who has recently suffered from, or been in contact with any dangerous infectious disease should be permitted either to milk cows or to handle milk in any way.

Meat may be unfit for food because it is decomposing or is diseased. A food-inspector should be well acquainted with the appearance of healthy animals, alive and dead. No beast which presents appearances of disease should be slaughtered for food; but animals injured by accident may be eaten as a rule. The inspection of meat is by no means an easy task: it cannot be learnt from books and nothing but constant attendance at a slaughter-house will familiarise the student with the aspects of the organs and carcases in health and disease. The following is a list of the principal diseases which lead to the condemnation of meat for food:—

Tuberculosis.	Liver flukes.
Anthrax.	Hydatids.
Puerperal fever.	Cysticercus disease.
Injuries.	Trichinæ.
Inflammatory conditions.	Actinomycosis.

Tubercle is fortunately a rare disease amongst cattle in the Madras Presidency. As a guide the recommendations of the Royal Commission on Tuberculosis may be cited.

A. The entire carcase and all the organs may be seized:—

(1) When there is miliary tuberculosis of both lungs.

(2) When tuberculous lesions are present on the pleura and peritoneum.

(3) When tuberculous lesions are present in the muscular system, or in the lymphatic glands embedded in or between the muscles.

(4) When tuberculous lesions exist in any part of an emaciated carcase.

B. The carcase, if otherwise healthy, shall not be condemned but every part of it containing tuberculous lesions shall be seized :—

(1) When the lesions are confined to the lungs and the thoracic lymphatic glands.

(2) When the lesions are confined to the liver.

(3) When the lesions are confined to the pharyngeal lymphatic glands.

(4) When the lesions are confined to any combination of the foregoing, but are collectively small in extent.

Butchers speedily become aware of the grounds for the condemnation of carcases and will remove as far as possible all signs of disease. Inspectors must be on the look out for such tricks as the removal of the pleura, diaphragm and lymphatic glands.

Anthrax.—There may be serous exudations into the pleura and peritoneum. The spleen is commonly enlarged, soft and filled with a substance resembling semi-coagulated blood. The intestines are congested and filled with blood-stained material, the flesh is moist and dark, rigor mortis is delayed and the blood coagulates very slowly. The carcase should be altogether condemned.

Puerperal fever.—The pelvic tissues and hind-quarters are mainly infected and are often removed by the butcher. The flesh is dark and putrefaction is rapid. The peritoneum, udder and uterus are evidently inflamed and pus and a foul odour may be detected. The whole carcase should be condemned.

Injuries and bruises.—The lesions noted must be distinguished from those caused by acute disease.

Only the damaged part need be seized, unless the formation of pus has occurred, in which case the whole carcase should be condemned.

Inflammatory conditions.—The flesh is dark in colour, flabby and moist and rapidly putrefies. If the animal has been treated with drugs such as turpentine, aloes or castor-oil, the smell of these may be noticed. If a suspicion of pyæmia or septicæmia exists, the carcase should be condemned.

Liver flukes are generally met with in sheep, more rarely amongst cattle. Pressure on the bile ducts will bring flukes into view. Unless the animal is greatly emaciated only the liver need be condemned.

Cysticercus disease is seen in the muscles of pigs and cattle, more rarely in sheep and goats. The cysts are about the size and appearance of a grain of boiled rice. The disease is sometimes spoken of as "measles," and is a stage in the life history of various forms of tape-worm. Measly pork or meat should be condemned.

Hydatids are another stage in the development of tape-worms. Large cysts are common in the livers of sheep and goats and should lead to the condemnation of the organ affected.

Trichinosis is not common in the Madras Presidency. The disease is commonest in pigs and is characterised by the presence of minute cysts in the muscles, particularly in the diaphragm, which can only be recognised by the aid of a lens. The carcase should be condemned.

Actinomycosis is a disease due to a streptothrix fungus. The lower jaw, tongue, bones, lungs are the parts most commonly affected. Local inflammatory swellings, with suppuration, occur and simulate tubercular lesions. The carcase should be condemned.

A very common parasitic disease of animals is *Psorospermosis*, characterised by the presence of numerous elongated whitish capsules, $\frac{1}{4}''$ long or less, in the muscles. It is so common that it would be impossible to condemn carcases which are affected by it, more especially as it is but rarely conveyed to man, only three cases having been reported in medical literature up to date (1910). The parasites are destroyed by thorough cooking. Sheep and sometimes oxen die from this disease.

Good meat.	*Bad meat.*
Should be red in colour, not too dark or too pale. The flesh of young animals is paler than that of old, and lamb, veal and pork are naturally paler than beef and mutton. The tint deepens with age. The flesh of a bull is darker and coarser than that of an ox. The *fat* should be pale yellow or white and firm.	The flesh of an animal dead from an exhausting disease is pale red in colour and the amount of fat is small. A livid *colour* indicates commencing putrefaction, later on a greenish tint is observed. The *fat* may be dark and soft.
The surface of the meat should be dry.	The flesh is flabby and moist.
The *marrow* of the bones should be fairly firm and pale pink in colour. The *odour* should be faint but not disagreeable. The flesh should be firm to the touch, elastic, and should not pit on pressure. No fluid should exude on pressure.	A bad odour is the first sign of decomposition and is early noticed in the marrow which becomes dark and soft.
The *reaction* should be acid.	In hot weather originally good meat decomposes first on the surface, particularly in the moister and more fatty parts. The *reaction* is alkaline. Moisture may exude on pressure from bad meat.
	Crackling of meat may be due either to gas formed by decomposition or to air blown in by dishonest butchers to make it appear more plump.

There is a tendency on the part of owners of animals to send them to the slaughter-house when they are no longer fit for any other purpose ; when

the cow ceases to bear calves and produce milk and the ox is too old and weak to pull a vehicle they are sold to the butchers. Hence a great many animals are brought up for slaughter which on account of age and emaciation are really unfit for human food, and it becomes the duty of the inspecting officer to reject such animals. Before any animal is permitted to be slaughtered it should be carefully examined by an experienced and competent Inspector, and before any carcases or organs are permitted to leave a slaughter-house or be sold they must be passed by the same official. The majority of animals which are brought to be slaughtered for food in India are in poor condition and are seldom fed for slaughter months beforehand as is done in Europe. Hence it is difficult to get really prime meat in India, though there is no reason why this should not be done just as well as in Europe. Want of enterprise and distrust of co-operative methods on the part of butchers and cattle-breeders are the real causes.

Fish decomposes more rapidly than meat. Unsound fish is limp, will pit on pressure, the eyes are sunken and dull and the gills pale and dirty looking. The smell is generally appreciable. The flesh is very easily separated from the bones. A great deal of badly preserved, dried and salted fish is exposed for sale which must not escape the notice of the Inspector. Fish, on being caught, if they cannot be preserved alive, should be bled and gutted to prevent decomposition setting in too soon.

CHAPTER III.

WATER.

Sources.

The total quantity of water on the earth and suspended in its atmosphere remains much the same from year to year, but its distribution is always varying. Evaporation is constantly taking place from all exposed surfaces of the earth under the influence of the sun's rays, and the water-vapour thus formed is diffused throughout the atmosphere. In time the vapour becomes condensed, first into cloud and then into rain or snow, and falls again to the earth. The rain which falls on the ground partly evaporates, partly sinks into the soil and partly flows over the surface till it forms streams and rivers which eventually discharge into great lakes or seas. Thus there is a constant circulation of the water going on.

The amount which evaporates depends on the temperature, dryness and movement of the air, and rate and quantity of rainfall; the amount which flows over the surface or sinks into the soil depends upon the inclination of the surface and the nature and dryness of the soil, as well as upon the rate and quantity of rainfall. The water, which flows over the surface and in surface channels, carries all kinds of impurities with it into the tanks, shallow wells and rivers, in which it finds storage or outlet, while that which sinks into the ground dissolves whatever soluble substances it may meet with in the soil, and, if sufficient in quantity, penetrates downwards until it meets with rock or impermeable clay, on the surface of which it flows slowly through the interstices of the porous soil, and forms the usual supply

of wells. The height of this subsoil water or ground water, as it is called, is shown by the level of water standing in ordinary wells ; there may sometimes be none, and it may vary greatly at different seasons of the year and in different places. It is affected by the level of the water in neighbouring tanks and rivers. Its rate of flow depends upon the inclination of the impermeable layers over which it flows and upon the porosity of the permeable soil through the pores and crevices of which it has to pass. Sub-soil water is sometimes retained in basins or hollows in the impermeable layer on which it rests. When the surface of the land in any place dips to the level of the sub-soil water, this flows out, forming a spring. Springs may also be formed when water in an elevated part of the country has entered between two impermeable layers, which slope downwards into a lower part of the country, and any holes or fissures in the upper layer permit the escape of water through it. Very deep wells, which are sunk into a water-bearing layer of this kind lying under an impermeable layer, are called Artesian* wells ; the water in such wells often rushes up with great force as may be seen at Pondicherry. Artesian wells are merely narrow borings 2 or 3 inches in diameter to a depth of 2,000 ft. or so.

Vast quantities of water are stored up in the form of snow and ice in the high mountain ranges of the earth from which the great rivers arise. Water is a necessity for the continuance of life in every living thing, and in the communities of mankind it is put to numerous practical uses. The great problem before the dwellers in cities is how to obtain sufficient good fresh water for domestic purposes and for manufactures. In agricultural districts water is needed just

* From Artois in France where the first one was sunk.

as much for the welfare of the crops, and men are concerned to store it for use in dry weather as well as to provide free outlet to excess in storms. The conformation of the ground and the amount of vegetation have a great influence on the circulation of water. Rain falling in hilly country tends to run off rapidly into valleys. This tendency is checked by forests and jungle which impede the progress of the water down slopes, give it time to soak into the ground and thus prevent floods. If a hill side is stripped of its forest there is nothing to impede the rapid flow down of storm water, the surface soil gets wasted away, and the water, which before would have flowed away slowly, rushes rapidly down and floods and devastates the low country, and so, that which once was fertile country becomes an unproductive desert.

Classification.—Drinking waters have been classified as to source and unwholesomeness as follows *:—

Wholesome	1. Spring. 2. Deep well. 3. Upland surface.
Suspicious	4. Stored rain. 5. Surface from cultivated land.
Dangerous	6. River to which sewage gains access. 7. Shallow well.

Water from any of these sources may be clear and of agreeable taste. Each of these natural sources of water has now to be considered.

Spring water is not likely to contain dangerous organic impurities: it generally contains very little organic matter of any kind, except when the spring is derived from alluvial soil; but it is

* By the Rivers Pollution Commission (England).

sometimes highly charged with mineral matter, which may render it unwholesome for drinking or so hard as to be unsuited for cooking and washing. As a rule, however, spring water is excellent for drinking. Artesian wells may be regarded as springs.

Deep-well water.—A deep well, technically speaking, is a well that passes through an impermeable stratum of the soil, and reaches a water-bearing stratum below. This water must necessarily have travelled some distance horizontally through the soil and is generally free from harmful bacteria. If, therefore, it can be protected from surface pollution, it will be a good and safe drinking-water. Surface impurities can be excluded by building an impermeable masonry wall, or steining, from the surface down to the level of the impermeable stratum, together with a cemented platform all round the mouth, so that surface-washings cannot percolate through the soil and contaminate the water in the well.

Upland surface water is the surface drainage of hilly ground, and its nature depends upon the nature of the surface soil. The water is usually collected by channels passing along the bases of the hills and delivering into storage tanks or lakes.

When the collecting surface consists of granitic or other igneous rock formations with little vegetation and no habitations upon it, such water is very soft and pure. Most commonly, however, the receiving area is covered with jungle or grass, and the detritus of this vegetable matter is carried down with the water during the rains, some of it remaining dissolved or suspended in the water, while the heavier portion, mixed with clay or sand, forms the alluvial sediment or silt, which is deposited in the bottom of tanks and lakes. Water derived from a surface of this kind is soft and contains little mineral, but a considerable amount of organic

impurity of vegetable origin. Of this nature are most of the tank waters in Mysore, Hyderabad, the Deccan districts and the Nilgiris. When the surface soil or rock contains soluble mineral substances they will be more or less dissolved by the water which flows over it ; for instance, some surface waters in Salem and Bellary become thus impregnated with magnesium carbonate from magnesite rock, some in Coimbatore and other places with calcium carbonate from limestone rock, and some in the southern districts with nitre or with common salt from the soil. It must be remembered that upland surface water, if near a village, is habitually defiled by the inhabitants and by domestic animals, the banks of the tank being converted into a latrine and its water used indiscriminately for receiving ordure and urine, for washing the person and clothing and for drinking. Hence it is most necessary that any tank, or channel supplying a tank, the water of which is used for drinking, should be very strictly guarded from such pollution. On the whole, it may be considered that upland surface water, if guarded from animal contamination and filtered if need be, to remove suspended vegetable impurity, is usually a good and wholesome source of supply.

Rain-water is systematically collected in Venice, Jerusalem, Lagos, Buenos Ayres, Demerara and parts of South Africa and Australia where the rainfall is scanty, from the roofs of houses or from prepared areas, which are paved or lined with cement, and it is commonly stored in underground tanks. Arrangements must be made in such cases to bye-pass the first washings which are contaminated with dust, excrement of birds and other foreign matter. With due precaution, rain-water thus collected and stored is very pure and good for drinking, while its great softness renders it the best of all natural waters for washing. Rain storage

though not very suitable to large towns where the air is impure and dust abundant and where pollution of tanks might easily occur, would form the best possible source of supply for drinking purposes in those parts of the country where well water is brackish * or hard, and where pure surface water is not obtainable, and it deserves the special attention of the district and village authorities and all large householders in every place which does not possess a good supply of drinking water from other sources. In some cases, even where a good supply might be obtained from deep wells, rain-water storage may be found more economical both as to first expense and as to secondary cost of raising water. Deep wells are preferable for the one reason that they are less liable to filth contamination. If rain-water storage be adopted, it is essential that the cleanliness of the receiving area, filters and storage tank should be regularly attended to. The receiving area may be the roof of a house or a sloping surface of ground paved with stone or cement and enclosed by a wall or fence. A ground area is preferable to a roof, because it is more easily inspected and cleaned. The size of the receiving area required to collect a given quantity of water in a year will depend upon the local rainfall, 25 per cent. being deducted for loss by evaporation, etc. The method of calculation will be described in the section on water-supply of villages. Rain-water thus collected contains impurities derived from the air through which the rain falls and the area upon which it is received; for the removal of most of these it should pass through a simple filter of gravel or sand before it passes to the storage tank. The capacity of a storage tank ought to be sufficient to contain enough water to

* Cornish recommended its use many years ago in parts of Malabar where the well water is bad.

last through the longest drought. The walls of the tank should be water-tight to prevent leakage and the entrance of impurity from outside, and the tank should be covered over and screened with wire gauze to exclude mosquitoes, apertures being provided for ventilation and cleansing. The deeper the tank in proportion to its capacity, the less will be the loss from evaporation. Such reservoirs may, with advantage, be excavated in the solid rock wherever this is possible. The use of covering over a reservoir is not only to exclude dust and prevent fouling by birds and other animals, but to shut out light and heat, and thus to discourage the growth of vegetable and animal life in the water and to limit loss by evaporation. A depth of at least 14 feet is also advantageous in storage tanks, open or covered, for the same reasons.

Rain-water, besides being stored in this way, may sometimes be usefully employed as a secondary source of supply to improve the quality of well-water which is hard or brackish. For this purpose the collected filtered rain-water may be led into the well instead of into a storage tank.

Rain-water is the purest form of water known in nature. If collected in clean vessels, the only solid matter it contains is derived from the impurities collected from the air through which it falls. These are naturally greatest in the neighbourhood of large towns where the air is polluted by factory chimneys, and the quantity of acid thus washed from the air has caused rain-water in certain places visibly to disintegrate buildings composed of lime stone.

Surface water from cultivated land is far more likely to be dangerously contaminated than water from any of the sources previously mentioned. The land around villages is commonly fouled by the inhabitants who resort to the edges of fields or

their neighbourhood for purposes of nature and wash themselves in irrigation streams. Such water is usually also polluted with the ordure and urine of domestic animals and with whatever manure is applied to the land; besides which it is certain to contain much vegetable detritus and perhaps mineral impurity. Therefore it should never be used unless no better water is obtainable, and then it should always be purified by filtration and boiling. Water from cultivated land which is not manured and has no houses or villages upon it, may be of good quality.

River water is always dangerous in India, except the water of mountain streams in uninhabited localities. During the rains, all kinds of surface dirt and filth, which has accumulated in nullahs, is washed into rivers, and the water is also turbid with suspended clay, and at all times the water of rivers and canals, which pass near villages, is polluted by the inhabitants. Sometimes dead bodies are cast into streams, or buried or burnt in their beds when the water is low. River water should, therefore, not be used if better water is obtainable, and if it has to be used it should be carefully purified. Deep wells sunk in or near rivers sometimes yield good water.

Shallow wells.—The quantity of water obtainable from a shallow well depends entirely on its surroundings. Here again we use the term "shallow" in a technical sense. In a shallow well no impermeable stratum is passed through before reaching the water. Nevertheless a shallow well may be in certain districts actually deeper than a "deep" well in other districts. There is nothing to prevent surface impurities reaching the water in a shallow well; even an impervious steining is only partially successful in this respect.

Shallow well water is usually the worst of all waters. Some of the shallow wells in or near villages are no better than cess-pools, and the people often drink their own diluted ordure and urine, mixed with those of domestic animals, and the washings of their bodies, clothes, and household utensils, along with all the other dirt which may find its way into the water from the surface and from the air. What wonder that such people are never free from intestinal parasites, and that they are debilitated and die by millions from diarrhœa, dysentery, cholera, and fevers? What wonder that their soil should be "the breeding-ground of cholera"?* Wells or small tanks which are more or less protected from direct surface contamination by masonry walls or steps are much better than ordinary shallow wells, but even they are liable to constant pollution from the feet of those who draw the water and from dirty utensils, and owing to their large open mouths they collect dead leaves and dust from the air in large quantity. One of the most urgent and primary sanitary measures required everywhere in India is the filling up of surface pools and dangerous shallow wells. While such sources of disease and death remain patent in every direction, municipal and local boards can have no excuse in not finding profitable employment for all the funds which are at their disposal for sanitary purposes. If much water be drawn from a well, the level of the water in it is lowered below the general level of the ground-water; the latter, therefore, for some distance around, flows towards the well and becomes depressed in the shape of

* The ancient Hindus were apparently more careful in avoiding defilement of water. Menu and the Shastras frequently inculcate personal cleanliness and ablution; but Menu also says that no man should cast into tanks " either urine, or ordure, or saliva, or cloth, or any other things soiled with impurity, nor blood, nor any other kind of poison." (Kanny Lall Dey.)

a funnel with curved sides of which the surface of the water in the well is the apex. All the drainage which filters through the soil above this funnel-shaped depression of the ground-water must pass into the well, and any surface pools or deposits of filth within a considerable distance around a well are thus likely to contaminate its water. The more a well is used, the deeper and wider becomes the depression of the ground water, and the more likely is such contamination to occur. Lining the upper part of a well with impermeable masonry does not protect it from this. It is true that surface filth may have to pass through a considerable thickness of soil before it reaches a well, and it may thus be effectually filtered for a time ; but if the surface pollution be continued, the soil eventually becomes contaminated throughout and it ceases to act as an efficient filter. Fissures in the soil may even allow of direct communication between wells and drains, sewers, surface pools, or other sources of contamination. The distance at which surface contamination may affect a well depends upon the local circumstances of each case. The height and direction of flow of the sub-soil water, the depth of a well and the amount of water drawn from it, and the nature of the soil are the principal circumstances which have to be taken into consideration. No possible source of contamination should ever be allowed to exist within 20 or 30 yards of a well, and this is often much too near to be safe. One eminent authority * considers that "the well should be at a distance of not less than 200 yards from the nearest house or drain, or cess-pool, or other source of sewage pollution." Wells should not only be placed at the greatest possible distance from any source of contamination, but on that side

* *Dr. Frankland.*—Evidence before Committee of House of Commons on Public Health Amendment Bill, 1878.

of it, from which the sub-soil water flows. If it cannot be ascertained in what direction the water moves, it may be taken for granted that it is with the general slope of the surface of the ground, such being usually the case. The upper portion of a well ought to be lined with impermeable masonry to prevent the entrance of direct drainage from the upper layers of the soil, which are the most impure. The ground should be made to slope away from the mouth of a well, and be paved with impermeable masonry for some distance round the mouth to prevent surface drainage from finding its way directly into the well or down on the *outside* of the masonry tube of the well. As an additional safeguard against such occurrences, the soil around the tube of the well ought to be puddled to as great a depth as possible. In places where the ground water is high, the level of water in wells must also be high; but even in such places there is much difference between deep and shallow well waters, although the water may stand at the same level in both. The shallow wells receive the surface drainage which may have passed through only a few feet of probably polluted soil; the deeper wells, with a water-tight masonry tube, tap the lower layers of ground water which have filtered through a considerable depth of soil. It may be suggested that in such cases it would be advantageous to sink wells on the tops of any hillocks or high ground so as to prevent surface percolation, and obtain water filtered through the greatest possible thickness of soil. It is advisable that the mouth of a well should be small in order to prevent the entrance of dead leaves, insects, dust, and impurities of all kinds as much as possible. For drawing water from a well, a pump or a public bucket should be provided, and no person should be permitted to employ a private vessel for the purpose; such a

vessel may be dirty and perhaps introduce disease-germs into the water. Wells require to be cleaned out occasionally, and provision should always be made for this, which may be most conveniently done at the end of the hot weather, when the water is lowest. The water of a well, which has not been cleaned out for a long time and has not been in constant use, will be found to contain an excessive quantity of organic matter. If a well has been disused for some time, it should always be cleaned before being again brought into use.

The main thing to bear in mind is that wells are by far the most frequently polluted by their mouths. Hence the necessity for a good parapet wall and an impervious platform around. The notion that well water must be exposed to the light if it is to be good is entirely erroneous; still, it is widely prevalent and is always brought forward as an argument against closing up the mouth of a well and introducing a pump. The water in a well with a closed mouth is both safer and better than that in a well with an open mouth. An ordinary suction pump theoretically lifts water 33 feet but practically it cannot be depended on to lift more than 25 feet. Force pumps which will lift any height are sometimes made use of in urban areas, but in villages the more primitive windlass and bucket will probably be found to be the most suitable form of lifting apparatus. The best and safest form of well is one which is dug out, steined down to the impermeable soil, and provided with an iron pipe reaching to the bottom, having numerous perforations at its lower end. The lower part of the well is then filled with large stones, which allow the water to accumulate in the spaces between them and serve as a support to a layer of gravel above them. On the gravel comes a layer of sand. The mouth of the well is protected by a parapet with a moveable cover over

it, and around it is a masonry platform and a fence to prevent any one from approaching it closely. Connected with the iron pipe is a pump, which should be fixed 20 yards away from the mouth of the well, and arrangements should be made to carry off all waste water from the pump by a drain.

To discover whether a cesspool or any other source of contamination actually has communication with a well, various innocuous chemicals can be added to the liquid in it, and the well water can be examined thereafter to see if the chemical has found its way into it through the soil. If the chemical can pass into the well, it is evident that harmful matter from the cesspool can do likewise. The most commonly used substances for this purpose are *fluorescein* and *ammonium chloride*. A quarter of a pound of the former added to the liquid in a cesspool can be detected by the greenish fluorescence it imparts to the water in the well, if it is present in the proportion of only 1 part to 100 million parts of water. Before using ammonium chloride the amount of ammonia normally present in the well water must be ascertained by analysis. At least 10 lbs. of ammonium chloride should be put into the cesspool. Chemical analysis will be able to detect an increase in the amount of ammonia in the well water.

Norton's tube well.—For the temporary supply of water in camps and during festivals this device is frequently useful. It consists of a steel pointed tube with perforations near its end which is driven into the ground at a spot where water is known to be and where the soil is not polluted. Lengths of tubing are screwed on to the first piece, and the whole is driven down by blows from a falling weight suspended on shears till the required depth is reached, when a pump is fitted to the top. When no longer wanted the tubes are withdrawn.

Useful facts to remember in connection with water are the following: —

One gallon of water weighs 10 lbs. (70,000 grains).
One cubic foot of water weighs 62·3 lbs.
Do. do. measures 6·23 gallons.

Storage and Delivery.

Collection of water.—As it is extremely important that people should be supplied with plenty of pure water, and as it is usually impossible to obtain it pure from wells or tanks in towns, it is frequently necessary to have recourse to artificial storage tanks, where rain water can be collected or a stream dammed back in a valley. Sometimes a natural lake suffices. Whatever the method employed may be, it is of the utmost importance that the catchment area, drainage area, or gathering ground of the storage tank should be carefully preserved from contamination, that is to say, that no human habitations should be permitted to exist within the area, that grazing of cattle be prohibited and that cultivation be stopped, for where there is cultivation there will be men and beasts and the land will be manured from time to time.

Another method of obtaining sufficient water to supply a town is by means of infiltration wells or galleries. A number of ordinary wells are sunk in a water-bearing stratum at a distance from the town and in unpolluted ground, and the water is pumped up and delivered by pipes directly, or better, through the medium of a storage tank. The "Seven Wells" supply of Fort St. George, Madras, is an illustration of this method, but the stratum which formerly supplied pure water has become polluted and the water is no longer safe for drinking. In other cases, galleries are cut alongside a sandy river and unjointed or perforated pipes are laid at the bottom and covered in with coarse gravel.

Water from the river filters through the intervening thickness of sand, being purified on the way, and is pumped up to a storage tank and then distributed. The ground water flowing towards the river is also intercepted by the gallery. The neighbourhood of such a collecting area must be carefully preserved from contamination. Several Southern Indian towns derive their supply from some such source as this.

Storage of water.—The presence of fish in a storage reservoir does no harm, and the larger water plants tend to purify the water by giving off oxygen under the influence of sunlight. Certain small water weeds, such as nostoc, and some minute unicellular algæ, often evolve most offensive odours. It sometimes happens that these minute algæ increase enormously in tanks, and later on, the conditions becoming unfavourable to them, they die off with equal rapidity, and decompose and greatly pollute the water. One remedy for this state of affairs is to remove the growth entirely, but that is rarely practicable. Another is to distribute copper sulphate in the water till it is present in the proportion of one in one million, which does not render it poisonous. Sometimes this has proved successful in killing off the vegetation, but the method has often failed. A foul tank in a town can often be purified and rendered inoffensive by introducing some large water plant, such as the lotus.

In addition to large impounding reservoirs, towns are generally provided with one or more service reservoirs which contain one or two days' supply.

Smaller *storage tanks* in towns should be of masonry, well covered in to keep out dust and bird droppings, and at the same time well ventilated. House storage cisterns should be of masonry, stoneware, or galvanised iron, covered in, ventilated,

and fitted with a tap to avoid the necessity of dipping possibly dirty vessels into them. Water kept in earthen vessels placed on the ground runs great risk of becoming contaminated, and all cisterns below the level of the floor of a courtyard should be condemned. Surface waters are generally improved by being stored in open reservoirs or tanks, as oxidation of the contained vegetable organic matter goes on, but sub-soil waters undergo rapid deterioration from the growth of algæ, unless kept in the dark. Deep well waters are not improved by storage; bacteria gain access and multiply greatly. No such multiplication is found in stored surface waters. The growth of bacteria and fungi is encouraged by dark storage.

Delivery of water.—From service reservoirs water should be distributed to the consumers by closed aqueducts and pipes. Every paka house should have its own connection, for there is always danger of contamination by the way, if people have to take their vessels to a common stand pipe at some distance; especially so if the distribution is performed by a hired man, who may be even less particular about the cleanliness of his mussacks or buckets. In India in particular all storage of water on the premises, whether in cisterns or in earthen or metal vessels, is to be avoided as far as practicable.

The supply of pipe water may be either *constant* or *intermittent*. The only advantage of the latter system is that there is less wastage of water. A constant supply is unquestionably safer and, if the fittings are carefully attended to, there should not be much waste.

It is impossible in India, where even in large towns numerous tiny mud huts are found, to have a tap in each dwelling. With a careless population much water is wasted by public taps being left

running by the last user and by destruction of taps through misuse. A tap, though simple, is a fairly delicate piece of mechanism, and one that is fool and mischief proof has yet to be constructed.

Impurities of Water.

Perfectly pure water is never found in nature. Natural waters always contain in solution some quantity of the gases of air and some solid matter, consisting of common salt and other minerals, and usually traces of organic matter derived from plants or animals. Besides such impurities in *solution*, natural waters always contain more or less impurity in *suspension*. Suspended impurities consist of insoluble mineral matter, such as fine clay, and of organic matter, which may be dead or living. The dead organic matter found suspended in water consists of minute dead plants and animals, or small particles of larger plants and animals, in various stages of decay; the living organic matter consists of living plants and animals, many being extremely minute microscopic organisms, and of their seeds and eggs. Some of the impurities, which may be contained in water, are beneficial, whilst others are noxious.

Among beneficial impurities in water may be mentioned the gases of which air is constituted, especially oxygen. These gases (nitrogen, oxygen, and carbon dioxide) render water sparkling and of pleasant taste. Oxygen and carbon dioxide are proportionately dissolved by water to a larger extent than the nitrogen of air.* Oxygen dissolved in water, besides being necessary to support the life

* The gases in water should consist of 8 to 10 per cent. of CO_2, 30 to 37 per cent. of O, 63 to 70 per cent. of N, the total amount of gases in a good potable water being from 25 to 50 cubic centimetres in a litre—*Dujardin Beaumetz.*

of fish and other aquatic animals, serves a very useful and important purpose in gradually oxidising and changing into harmless inorganic matter the decomposing organic matter which may be dissolved or suspended in the water. Carbon dioxide gas dissolved in water affords nourishment to green aquatic plants in the same way that in the air it affords nourishment to green terrestial plants, and it also renders soluble calcium carbonate, magnesium carbonate, and other carbonates which are little or not at all soluble in pure water. For the latter reason an excess of this gas is sometimes detrimental.

A moderate quantity of dissolved mineral matter in water is not unwholesome and is probably beneficial in cases when the food is deficient in salts.

Water is rendered *hard* by calcium and magnesium salts and carbon dioxide gas, and its hardness depends upon the quantity of these impurities which it contains. Hard water does not easily wet the skin, nor wash off dirt from clothes, and much soap is required to form a lather with it. It is, therefore, even when fit for drinking, bad for washing purposes. It is also, unless the hardness be due to carbon dioxide only, bad for cooking, because vegetables and other food stuffs cooked in it are tougher than if cooked in soft water. Hard water of the same kind is unfitted for steam and most manufacturing uses, and it deposits a crust or fur on the interior of boilers.

Water which has a saltish taste, usually due to common salt, is said to be *brackish*, but water which is too brackish for drinking may sometimes be fit for cooking.

Among suspended impurities, the presence of live fish, molluscs in moderate quantity, and large water plants, as well as of minute green algæ and diatoms, may be considered generally beneficial and

purifying in rivers and shallow tanks, though they may exist in many bad waters. The absence of fish and molluscs in perennial rivers and tanks usually denotes very bad water.

The noxious impurities in drinking water are: (1) dissolved minerals in excessive quantity or of a poisonous nature, such as excessive quantities of calcium and magnesium salts, or even a small quantity of lead; (2) suspended mineral matter, such as clay or sand; (3) dissolved organic matter; (4) suspended organic matter, including vast numbers of micro-organisms. In the absence of harmful bacteria, the mere presence of organic matter in the water does not necessarily do harm especially if those who drink it are used to it: it is likely however to cause diarrhœa or otherwise disagree with persons who are used to a pure water. The micro-organisms found in water may be divided into two classes; (1) saprophytes, which live in natural waters and are harmless; (2) parasites, which are not found in natural but only in polluted waters. The latter will be alluded to by the term *pathogenic*, or disease causing, organisms. The organic matter in water forms food for the micro-organisms, consequently the purer a water the fewer the bacteria in it, and the number of bacteria found in a given volume of water can be said roughly to constitute a measure of the purity of that water. The basis of all endeavours to obtain a pure water in the first place, and to preserve it from all chance of contamination before it has arrived in the consumer's hands, is the fact that pathogenic micro-organisms are not found in waters uncontaminated with waste and foul matters derived from animal sources.

The eggs or immature forms of various parasites may also be contained in polluted water and thence gain entrance into the human body where they become developed.

Impurities may gain access to water at its source: these are largely dependent on the geological formation of the district. Water has greater solvent power than any other known liquid and it dissolves mineral matter from almost every kind of rock with which it comes into contact. A considerable amount of suspended vegetable impurity may be present in a surface water and, if the collecting area is not well conserved, of animal impurity also.

Between the source and the service reservoir, if open aqueducts are employed, surface washings with all their contained impurities, inorganic and organic, dust, leaves and refuse of all sorts may find their way into the water.

During the storage of water in tanks, wells or cisterns, whether public or private, the chances of contamination are great. During distribution by hand, noxious matter may easily find its way into water, and even pipe distribution is not entirely free from danger as impure air, dirty water, or sewage can be sucked into pipes through defective joints.

The business of efficiently guarding water from contamination from its source till it is actually used by the consumer, is evidently not a simple matter, and is one that demands constant and minute attention on the part of the sanitary and engineering staff of a town.

Diseases due to Impure Water.

Insufficiency of supply, even though the available quantity be above reproach, leads to numerous troubles. Washing, both of person and clothes, becomes a difficulty and is neglected; houses, streets and drains cannot be properly cleaned and a general state of dirt and unhealthiness prevails. People, moreover, are driven to use whatever water they can obtain, even though it be foul, from tanks,

wells and other collections which they would not otherwise touch.

Functional Diseases.—Suspended mineral matter such as clay and fine sand will cause mechanical irritation of the alimentary canal and diarrhœa in persons unaccustomed to it.

Dissolved mineral matter such as sulphates in excess will give rise to purging. Hard waters containing calcium, magnesium and iron may constipate, and possibly have some influence in the production of stone in the bladder and goitre. Lead poisoning may result from the use of lead pipes, fittings or cisterns, when the water is soft.

The Bacterial Diseases which are conveyed by water are always due to the contamination of the water by fœcal matter. The best known are cholera, typhoid and various ailments included under the heading of dysentery.

Certain Parasitic Diseases are communicable by water when the eggs or embryos of the parasites have accidentally found their way into the supply. In some cases water is the habitat of the intermediate hosts of the parasites. The complete life-history of many of these parasites has not, however, yet been worked out and it is uncertain how far water is the medium for their distribution.

Such parasites are ascaris lumbricoides (round worm), oxyuris vermicularis (thread worm), distomum hepaticum (liver fluke), filaria dracunculus (guinea worm), anchylostoma duodenale, filaria sanguinis hominis, bilharzia hæmatobia, leeches, and, probably, several other nematode worms and intestinal flagellates.

Exclusive of specific disease, the use of polluted water may not, in those accustomed to it, produce obvious illness, but it leads to impairment of health and increased liability to disease of many kinds.

New arrivals, however, drinking the same water may immediately suffer.

The Purification of Water.

Natural Purification.—Purification of water constantly occurs in nature. Sub-soil water is surface water which has been purified from suspended matter by filtration through the earth. Organic impurities, whether suspended or dissolved in water, are gradually destroyed by oxidation, the oxygen which is dissolved in all natural water being the main purifying agent. The oxygen of the air also acts directly upon impurities at the surface. Water in commotion becomes much more rapidly purified than still water, because the impurities are constantly being acted upon by fresh portions of oxygenated water; after they have removed the oxygen from the portions of water with which they were first in contact, they are exposed to atmospheric oxygen as they are tossed about on the surface, and the water is kept well oxygenated by free exposure to air. The presence of certain bacteria appears to be necessary for the destruction of many organic impurities; putrescent nitrogenous matter is converted by them into ammonia, and this is further converted into nitric acid. The action of sunlight in purifying water has probably been overestimated; though it will destroy bacteria growing in a test tube, it is hard to estimate what effect it has on turbid water a few inches below the surface. Sedimentation plays a large part in the natural purification of water. Organic and inorganic suspended matter gradually settle to the bottom and the former is in time nitrified. It must be remembered that water is not the natural habitat of pathogenic organisms such as those of cholera and typhoid, and though they may live and multiply for a while, they gradually tend to die off

when introduced. In addition they have to contend against the saprophytic bacteria naturally found in water in the struggle for existence. In deep wells, and sterile water which contains no saprophytes, they may, however, survive for months.

ARTIFICIAL PURIFICATION.—Our forefathers were content with the *physical* purification of water. As long as it was clean and bright and tasted well they were satisfied. Further knowledge led to care being taken to obtain *chemical* purity by the removal of dissolved noxious substances. Lately great attention has been paid to securing *biological* purity: the freedom of water from the micro-organisms which are the cause of disease, and to this end all our efforts must be directed. The objects of artificial purification of natural waters are to get rid of excess of dissolved mineral matter and to remove suspended impurities, both vegetable and animal, living and dead. According to their nature and origin, different waters require different methods of treatment, and methods which are applicable on a large scale to a town supply are not always applicable on a small scale as domestic safeguards, and conversely.

Distillation.—By distillation, water is obtained nearly absolutely pure; organisms are destroyed, the solids are left behind and dissolved gases only pass over. This method is used for obtaining potable water on board ship, and in places where little or no fresh water exists, such as Aden. Distilled water is, however, unpalatable unless aerated.

Boiling drives off the dissolved gases of water, including CO_2, whereby chalk is precipitated. Bacteria are killed, but not necessarily all their spores. The worst water can, however, be rendered safe to drink by boiling, and it is a process which should never be neglected whenever the purity of the water

obtainable is questionable. It has the disadvantage of rendering the water less palatable until it has been again aerated, and it is tantalising when thirsty to have to wait until the boiled water cools down. It is, of course, useless to boil water and to cool it down by the addition of cold unboiled water. Both boiled and distilled water when cooled must be carefully preserved from contamination, since no living bacteria are present, and any which find entrance will, therefore, be able to multiply unhindered.

Sterilisation by Heat.—To get over the difficulty of having to wait for water to cool after being boiled, various forms of apparatus have been devised with the purpose of delivering sterile water at a temperature low enough for immediate drinking. The heated water is carried through the unheated water and, while being cooled, serves to economize fuel by warming up the latter. This apparatus is of use chiefly to travellers and armies on the march.

The Addition of Chemicals.—This is done with three objects in view, viz., to clear suspended matter from water, to soften it and to sterilise it.

(1) *Alum*—added in solution in the proportion of about 6 grains for every gallon of the water to be treated, forms in hard waters a bulky precipitate of aluminium hydrate, which settles to the bottom and carries with it much of the suspended matter, including bacteria. Care should be taken not to add more alum than is actually required to form a precipitate, otherwise the water will be rendered unfit to drink. The water should be poured off as soon as subsidence is complete, as those of the sedimented organisms that have not perished rapidly multiply and find their way back to the water.

(2) The vaunted *Indian clearing nut* (strychnos potatorum), the juice of prickly-pear

leaves, and such like substances, may be practically neglected except as household remedies when nothing better is available. The former contributes a bitter and the latter a sickly taste to the water.

(3) *Clark's process*—is designed to remove the temporary hardness, *i.e.*, dissolved chalk, from the water by precipitation. Limewater is mixed in by mechanical means and this combines with the CO_2, which holds the chalk in solution, and causes the chalk to be precipitated. The precipitate is allowed to settle or is strained off. The permanent hardness due to the presence of sulphates, nitrates and chlorides of calcium, magnesium and sodium is not affected by this process.

It is exceedingly important to remove as much of the hardness of water as possible for dietetic reasons, and especially of a public water-supply, to prevent the incrustation of boilers, and wastage of soap. In cooking with a hard water, lime salts are deposited on the surface of the material, which hinders extraction in the case of tea and renders tissues hard in the case of meat and vegetables. Sodium carbonate softens water for washing, but cannot be used in cooking.

(4) *Potassium and sodium permanganates*—readily part with their oxygen in the presence of oxidisable organic matter in water and gradually render it harmless. Permanganate is used for purifying the water of wells and small tanks. It is supposed to have a specific action on the cholera bacillus and many medical officers have reported most favourably on the influence it has had in controlling epidemics of cholera when the water-supplies have been systematically treated with it. Others, including the writer, have not noticed any great change for the better which could fairly be ascribed to its use. In the extremely dilute solutions in which it is generally used, it is hardly

likely to injure the cholera bacillus itself, but it may indirectly affect it by oxidising its food materials in the water. A handful of the salt should be dissolved in a vessel of water and the solution added to, and thoroughly mixed with, the water in the well under treatment. As oxidation proceeds the pink colour disappears, and the only test that a sufficiency of the salt has been added is a pink colouration of the water which lasts not less than 12 hours.

The water is in no way injured by the process as the salt is non-poisonous, but the pink solution has a faintly disagreeable taste. The colouration and taste have their advantages in that they tend to keep people from using that particular well for a time.

To destroy bacteria, a 5 per cent. solution of the salt is required. This renders the water quite unfit for drinking for a long time, and if the treatment of water is being carried out on a fairly large scale, the cost of the salt generally will prohibit its use in this strength.

(5) *Ozone* is now used for the sterilisation of water in bulk in several towns in Europe, but a special apparatus is required for its manufacture and application. Air ozonised by electricity is either mechanically mixed with the water or pumped into the bottom of a tower filled with stones over which the water trickles. Pathogenic and most water bacteria are destroyed but not spores.

(6) *Sodium hypochlorite* is the only chemical which has been used for the sterilisation of water on a large scale. It owes its power to the liberation of free chlorine in the water, of which one part in a million acting for an hour destroys most bacteria.

(7) *Copper sulphate*, 1 part in a million of water, as mentioned before, is used for preventing the growth of confervæ in water. For the purposes of sterilisation as much as 1 in 10,000 may be required, depending on the quality of the water, and this is

more than can be drunk with impunity, at least for prolonged periods. Merely keeping water in copper vessels, even for 24 hours, cannot be relied on as a measure of safety.

(8) *Tablets* of various chemicals can now be bought at most chemists which are designed to set free chlorine, bromine or iodine in the water, and any resulting taste or colour can be removed by the addition of another tablet. While in camp or travelling these tablets may be relied on to render a suspicious water safe to drink, provided that they are properly used and that the chemical composition of the water is not such that it uses up the greater part of the available bactericidal element.

Many other processes having in view the purification of water and involving the use of different chemicals and special apparatus are in use in various parts of the world, but for the present at any rate, they seem to be inapplicable in India.

Filtration.—The object of filtration is to remove noxious impurities from drinking water; that is, all suspended matter, inorganic and organic, including bacteria. During the process the dissolved constituents of the water are also changed to some extent.

Gravity filters.—For the purification of a town water-supply on a large scale, filters are frequently constructed of sand and gravel after the model of the earth which is one of the best filtering media known. A sand filter consists of a layer of clean sand 2–3 feet in thickness supported on a bed of gravel about 3 feet thick. The area depends on the quantity of water to be filtered. The depth of water above the surface of the sand should not exceed 1 foot and the rate of filtration should not be greater than 4 inches of water per hour. This allows about 2 gallons to pass through each square

foot of filtering surface per hour. When a filter is first brought into use the water passes through without appreciable purification. Gradually the interstices become obstructed and a slimy or gelatinous layer forms on the surface and the filtrate becomes purer, until, when working at its best, from 95—98 per cent. of the organisms present are arrested. The slimy layer increases in thickness and the rate of filtration becomes slower and slower until it becomes necessary to clean the filter. This is accomplished by removing the slimy substance and the upper half inch or so of the sand, and the remainder is stirred up and exposed to the air. When the sand by repeated removals of the surface layer has been reduced to the thickness of one foot, the whole must be taken up and cleaned and a fresh quantity added. The intervals between cleansings depend on the amount of sediment in the water under treatment. The slimy layer consists of finely divided mineral and organic matter, bacteria and algæ. The action of such a filter is partly mechanical and partly vital, and the removal of bacteria from the water is effected by their arrest in the fine meshes of the slimy layer, the formation and preservation of which is therefore the essential feature of the sand filter. Although no universal rule can be laid down, it is generally accepted that the filtrate from a sand filter should not contain more than 100 bacteria per cubic centimetre. The greater number of the organisms are retained by the upper inch of the sand: below the upper six inches very few can be recovered. Daily bacteriological examinations of the filtrate should be made and if, at any time, the standard fixed on is exceeded, the filtrate should not be delivered to the town but allowed to flow away down a bye-pass. It is evident that at least two separate filters are necessary, each of sufficient capacity to filter the whole supply required,

so that one may always be in working order while the other is being cleaned or otherwise attended to.

Properly worked and systematically tested sand filters provide a good and reliable filtrate, but if left without skilled supervision, they afford no protection whatsoever.

Mechanical or Pressure filters.—Of recent years sand filters have lost favour on account of the large area of ground they occupy, the difficulty of getting sufficient sand, the slow rate of filtration, the expense of cleaning and the care required to obtain uniform and satisfactory results. As good results can be obtained by automatically mixing aluminium sulphate with the water to be filtered in large steel drums. The water is then forced by pressure through sand on the surface of which the precipitated aluminium hydrate forms an artificial slimy or filtering film. The impurities collected are washed out in a few minutes by reversing the current of water through the apparatus, the process being assisted by revolving arms in the interior, and continued till the water runs clear. The output of these filters may be fifty times as great in the same time as that of a gravity filter of the same area, the initial cost of installation is less, the filtering material does not require to be changed and the annual upkeep is comparatively small. It will be clear that this system has many advantages over the ordinary gravity sand filter, but it does not appear to remove organisms quite so well.

If the water to be filtered is very soft it may be necessary to add lime water to it to act as a precipitant with the aluminium sulphate.

Domestic filters.—Animal charcoal, spongy iron, polarite and numerous other substances have been used as filtering media, chiefly on a small scale in domestic filters. Some of these act mechanically, and others chemically by oxidation, but none can be depended on to remove organisms; in fact unless

carefully looked after by someone who understands them, they are liable to become breeding grounds for bacteria and actually to increase the number of organisms in water that has passed through them.

If a town water-supply is properly filtered before delivery, the use of domestic filters is to be discouraged as unnecessary and at times even dangerous. The filters provided at the stations of some of the great Indian Railways must be classed as useless, if not actively dangerous, fixtures. Filtering through cottonwool, closely packed in a glass or tin funnel, is a ready and useful way of removing the coarser suspended impurities from water, but bacteria are not arrested by this medium. The "three chatty filter" so frequently seen in Southern India, if in the possession of a person educated to look after it, may serve a useful purpose, but as it is generally used it can only be condemned as leading to a false sense of security. If the public water-supply is unfiltered and open to suspicion, domestic purification becomes a necessity. Only two ways of removing bacteria are certain: (1) by boiling, (2) by the use of filters of the pattern of the Berkefeld or Pasteur-Chamberland. These consist of cylinders or "bougies" or "candles" of porous material through which water is forced under pressure or by the action of gravity. The pores are sufficiently fine to arrest all bacteria while allowing the water to pass through, and it is consequently obtained quite sterile. The bougies can be adapted to fit common water taps, for use in a force pump for travelling, or as ordinary filters actuated by gravity. These types of filter differ from one another chiefly in the size of their pores, the bacteria which are arrested on the outside grow through sooner or later and appear in the filtrate. The larger the pores the more rapid the rate of filtration

and at the same time the more rapidly are bacteria able to grow through. The more sediment in the water the more frequently is cleansing necessary to remove the deposit on the outside which obstructs the flow of water through the bougie. Sterilisation of the bougie by boiling or other means is also necessary to destroy organisms which are growing through the pores. In the case of a Berkefeld filter, which has the coarsest pores, sterilisation should be performed every third day; of a Pasteur-Chamberland, once a week. Though mostly used as domestic filters, these forms are now fitted up in "batteries" for the purification of water in aerated water factories, and even for the filtration of a public water-supply. Batteries of filter candles must always be looked upon with suspicion, as it is always difficult to detect cracked cylinders and leaky fittings. A single cracked candle will nullify the whole battery. The same applies to single candles used in domestic filters, a crack which is too fine to be noticed, or a bad joint, will let impure water pass, so that one can never be sure of the efficiency of a domestic filter unless the filtrate is regularly tested for bacterial purity in a laboratory. The conclusions one is forced to are, that no form of domestic filter can be relied on for general use for giving continuously a safe drinking water, and that, if the only available supply is open to suspicion, the only safe plan is to boil it; on no account should it be filtered after boiling.

The Water-supply of Towns.

The question of water-supply for large towns need not occupy much space here, because it is a question which should in every case be referred to the consideration of highly-trained sanitary and engineering experts. Some knowledge of it,

however, must be regarded as indispensable for all municipal authorities.

The water should, as a rule, not be derived from any source within a town. Surface wells should on no account be used, and any which exist ought to be filled up with earth. Even deep wells situated in towns are very liable to pollution ; the more they are used, the more likely are they to be fouled, for, according as the water is lowered, the area drained by a well is increased ; and the chances of direct pollution are manifestly greater in towns than in the country. Rain-water collected in large towns is also apt to acquire dangerous impurities from dust in the air and dirt on the roofs of houses. The water-supply of towns should, therefore, be obtained from a pure source outside. Springs, deep wells, up-land surface water and filtered river-water are the sources from which towns may be supplied ; and the source available, or the one selected where there are several, must depend upon local circumstances in each case. With regard to quality, it is desirable that water for a public supply should be not only free from dangerous organic and mineral impurities, but that it should be soft. Hard waters are not good for washing, nor generally for manufacturing purposes, and they may cause blocking of pipes from calcareous incrustation ; while the only possible objection to soft waters is that they are more likely to act on leaden pipes.

Waters which are derived from a peaty soil in a mountainous district are naturally acid and will dissolve lead energetically. This may be prevented by the addition of sufficient lime water as the supply enters the storage reservoir to neutralise the acid. The quantity of water required per head of population depends largely upon local circumstances, such as the use of public and private baths, water-closets and latrines, sewerage, clothes-washing,

manufactures and road-watering. Domestic animals have also to be provided for. and good drinking water is necessary for their health.

Clothes are frequently washed in very foul water, and the construction of public troughs or wash-houses, supplied with pure water, for the use of washermen free or on payment of a small rent, is a matter which deserves the attention of municipalities.

There is always a good deal of wastage in public water-supplies, and much of this is often preventable by proper control. Such control is most necessary when the supply is limited, or when the water has to be pumped up at considerable expense or to be purified, or when it is important to limit the quantity of sewage outflow.

In cases where the supply of good water is limited, it may be necessary to use it only for drinking and cooking, water for other purposes being obtained from less pure sources. A dual supply of this kind is, however, very objectionable, because it is certain that careless people will use for all purposes the water which is most easily obtained.

The quantity of water required for drinking and cooking may be set down as 1 gallon per head of population daily, and for all purposes 12 gallons per head is a sufficient, and 15 gallons an ample, supply for a town, if waste be prevented. With a large margin for waste and ornamental fountains and gardens, 30 gallons or more may be used. If many factories exist in a town, the quantity required for industrial purposes has also to be taken into consideration.

Aqueducts or channels for conveying water require great attention to prevent fouling of the water in them. The Romans carried pure water from great distances into towns by solid masonry aqueducts, laid sometimes underground and

sometimes supported on lofty arches according to the level of the ground. These aqueducts were so well built that the city of Rome still possesses a copious supply of excellent water delivered by several of them. Large iron pipes are now generally used for the purpose, and they are found more convenient and less expensive as they may be carried over undulating ground, and are able to resist a high internal pressure. They should, however, be bedded on firm foundations to prevent leakage of joints, and air valves must be provided at the summits of curves to permit the egress of air which always finds its way into delivery pipes, and sluice valves at the bottoms of curves, to allow collected silt to be washed out. Open channels such as that leading from the Red Hills to Kilpak * are very objectionable and can never be properly conserved; for this open aqueduct a closed conduit is now being substituted. For delivery of the water in the town, iron pipes should be employed. Lead pipes or cisterns should be generally avoided in India, for most Indian waters contain a considerable amount of nitrates and may become poisonous by contact with lead. Peaty waters are very apt to attack lead. Hard waters, and especially those containing silica, are not likely to dissolve lead. Unfiltered muddy water, such as Red Hills water at some seasons, is apt to cause choking up of pipes from silt, and some kinds of hard water produce the same effect by a deposit of calcareous material on the interior of the pipes. Fish or other animals, alive or dead, may enter water-pipes with unfiltered water or through leaky filters† and cause stoppages in pipes or pollution of the supply.

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* In Madras.

† Eels have lately obtained access to the pipes of one of the London water companies in this way and caused much annoyance. Fish are sometimes found in Madras water-pipes.

Water-pipes, especially in a descent, are likely to admit gaseous, liquid, or even solid impurities through leaky joints; care should, therefore, be taken not only to provide solid foundations for such pipes, but to avoid laying them in polluted soil or close to sewers. If this cannot be avoided, the pipes should be bedded in concrete.

The distribution of water in a town should be such as to place an abundant supply within easy reach of every house. Numerous public fountains situated at convenient centres will be found sufficient and safest in most cases; but, if the supply be constant, separate supply pipes may be laid to private houses and public buildings, and the pressure of water ought to be sufficient to carry it to the top of the highest building in the town.

Taps should be inserted at convenient intervals in the water mains laid through streets, in order that a ready water-supply may be obtainable for extinguishing fires and, if possible, for watering the roadways. The supply and pressure of water should be as *constant* as possible. An *intermittent* supply is very liable to contamination: when the water is shut off, foul air or liquid and even solid matters are likely to be sucked into the pipes through leaky joints or open taps.

If, for repairs or other reasons, the supply has to be shut off for a time, danger may be obviated, when the water is turned on again, by leaving some of the terminal taps open until the pipes have been sufficiently flushed.

In cases where there is a threatened failure of the water-supply of a town, owing to a long drought or other cause, the common and, as above pointed out, dangerous practice is to render the supply intermittent by shutting it off except during certain stated hours daily. Danger would be avoided and

waste would be better controlled if, instead of shutting off the main supply, municipal authorities were, in such cases, to seal up a number of the least required taps and fountains, and, if necessary, to limit the flow of taps by the insertion of perforated plugs or some similar device.

To render the water-supply of a town perfect it is necessary, not only that an abundant supply of pure water should be distributed to every part, but that every local source of polluted water should be closed. It is well known that numerous foul wells and tanks exist in Calcutta, Madras, and other cities and towns, which possess a comparatively good public supply of water, and that the inhabitants make free use of such contaminated sources, even in the close vicinity of public fountains. So long as filthy and contaminable sources of water are allowed to exist within municipal limits, no town, however pure and abundant its supply may be, can be considered well supplied with water or safe from outbreaks of those diseases which are communicable through water. Questions often arise as to the necessity of filtering a public water-supply. If the source of supply is from rivers or collected surface water in the plains, the water must be filtered to render it safe. If, however, it is derived from a mountainous region and is collected in a natural mountain lake or artificial reservoir, formed by building a dam across the mouth of a valley, and the water is of sufficient natural purity, as is usual in such circumstances, filtration is not a necessity provided that the catchment area can be rigorously preserved from contamination by human beings and cattle. It must be borne in mind that fœcal contamination is the more dangerous the nearer it is to the consumers of the water. The bacilli contained in the excreta of a person suffering from cholera deposited on a mountain side

would be less likely to survive and infect the consumers of the water derived from that area than if they had obtained access to the storage reservoir near its outlet. Again cholera-polluted sewage finding its way into a leaky delivery pipe would be still more dangerous. So the nearer the water is to the consumer, the more carefully must it be guarded from pollution. It would not always be necessary to filter a town supply derived by pumping from deep wells, but everything depends on local conditions.

The calculation of water-supplies for towns, the construction of weirs, storage tanks, well-tunnels, etc., and many other matters relating to large water-works are peculiarly the province of sanitary engineering experts and cannot be discussed here.

Water-supply of Villages.

The town population bears only a small ratio to the rural population of India; the water-supply of villages, therefore, demands even more attention than that of towns. Towns can generally command the services of specially trained and experienced sanitary and engineering authorities; but villages have, in most cases, to depend upon their own or their district officers for advice and supervision regarding the water-supply, and, indeed, for sanitary improvement generally. Hence it is most important that those officers should be capable not only of giving advice, but of carrying their advice into practice. Many portions of the preceding remarks as to the qualities and sources of waters and the water-supply of towns, are equally applicable to the supply of villages and detached houses, and they should be borne in mind when reading the following observations which are particularly intended for village authorities and house-holders.

We shall consider the water-supply of villages with regard to source, quantity, purification and distribution, premising that combined action on the part of the inhabitants will usually be required to secure a really satisfactory and safe supply.

Existing sources should first be examined and their water should be tested with the view of deciding whether one or more of them may be used for a general supply and whether they are capable of improvement or not.

Springs are rarely available, and the choice of good sources will generally be between deep wells, stored rain, and upland surface water. Deep wells and upland surface water have been already sufficiently discussed. Stored rain water is, however, such a valuable source, and one so little used in India, that some further remarks upon it may be useful. From this source pure drinking water could be readily obtained in places where well waters are brackish or unwholesome from their hardness and the presence of magnesium or other mineral impurities or from organic impurity, and where surface waters are liable to contamination. Such places exist in nearly every district. Large surfaces of rock may sometimes be utilized as collecting areas, the water being received in a channel cut along the lower edge of the surface and delivering with the intervention of a small filter into the storage tank. If a rock surface is not available, stone or brick may be employed for paving the selected area, or its floor may be puddled and lined with mortar, or what is better, Portland cement. The surface ought to have a sufficient incline to allow the rain to run off rapidly, and thus limit the loss by evaporation. The prepared area must be surrounded by an impenetrable fence or high wall, to prevent its defilement by men or other animals. A prepared surface of this kind is better than a

house roof for collecting rain, being more easily inspected and cleaned, and a roof is not generally large enough to yield a sufficient supply. It may be found convenient in some cases to use both roofs and ground areas. If it be determined to supply a whole village with rain water it is much better to have one large properly-made collecting surface and storage tank, which can be more easily looked after and kept clean than several small ones.

The *quantity of water* required, and the consequent size of the collecting area, will depend upon whether water for all purposes, or only for drinking and cooking, is to be supplied from this source. In places where the rainfall is sufficiently abundant, and where a large collecting surface can be provided, it may supply water for all purposes, at least 5 gallons per head (including children) daily being allowed. In places where the rainfall is scanty, or where long periods of drought are frequent, it may be possible to supply only water for drinking and cooking purposes from it, at least 1 gallon (8 pints) per head being allowed. To calculate the size of the collecting surface required, the first thing to ascertain is the average rainfall for as long a series of years as possible. If no observations of rainfall have been made at the place itself, the records of the nearest meteorological station may generally be accepted. One inch of rainfall yields a little more than half a gallon (0·5198) for each square foot of surface. The method of calculation can best be explained by an example. Let us suppose that it is required to obtain a supply of 5 gallons per head daily for a village containing 450 inhabitants, the average annual rainfall of the place being 28 inches. The total quantity of water required in the year will be the population multiplied by the daily amount per head multiplied by the number of days in a year $450 \times 5 \times 365 = 821{,}250$

gallons. As each inch of rain yields half a gallon on a square foot, 28 inches yield 14 gallons on each square foot and $821,250 \div 14 = 58,661$, which is the area in square feet necessary to collect the required supply. As an allowance for wastage by evaporation, leakage, etc., 25 per cent. may be taken, thus making the area $\frac{58,661 \times 4}{3}$, or 78,215 square feet, that is, a space measuring, if square, $\sqrt{78,215}$, or nearly 280 feet on each side.

The average annual yield in gallons of any existing surface may be calculated by measuring its horizontal area in square feet, multiplying this by half the average annual rainfall in inches, and deducting one-fourth for wastage. If the incline of the surface be slight no allowance need be made for its divergence from a horizontal plane; but if the incline be considerable a correction must be made, for instance, a pointed roof must be reckoned as a flat roof, covering the same house. Any surveyor, or other person accustomed to take levels, can easily make the required calculations for a ground surface.

The construction of a *storage tank* for rain water has already been alluded to; its capacity has now to be discussed. In most parts of India very little rain falls during the first 6 months of the year: storage for at least 6 months' supply will therefore be required. The rainfall of the driest year likely to occur may be taken at not less than half the average rainfall, and in such a year only half the usual supply would be collected. It may therefore be generally reckoned that a good storage tank ought to have a capacity equal to nine months' supply—that is, three-fourths of the annual requirements. In the case above supposed of a village with 450 inhabitants requiring 5 gallons each daily, or 821,250 gallons in a year, the storage tank ought

to have a capacity of $\frac{821,250 \times 3}{4}$, or 615,938 gallons, or nearly 98,700 cubic feet. (6·24 gallons = 1 cubic foot.) A reservoir, 23 feet deep, 23 feet wide and 172 feet long, would have the requisite capacity, and it should, if possible, be covered over. In any case it should be protected by a fence. Storage tanks ought to be built in two or more compartments for convenience of cleaning.

Although unfortunately the circumstances of few Indian villages would admit of the construction of reservoirs of this kind to supply 5 gallons per head daily, yet many villages could probably afford to construct reservoirs to furnish drinking water only. An area and tank of the size mentioned would be sufficient to supply drinking water only (1 gallon per head per day) for a population of 2,250 persons.

If the catchment area were considerably increased, so as to take better advantage of occasional showers during the dry season and light monsoons, the storage tank might be made smaller still. If this were done, and if care were taken to restrict the consumption to actual requirements in times of drought, a storage tank to contain only a four months' supply (at 1 gallon per head daily) might be made to suffice in many places.

Smaller reservoirs would be very useful in places where deep wells yield a good supply at certain seasons of the year, but occasionally run dry. The reservoir could be filled from the well and used as a reserve source when the well ceased to yield.

A less costly plan than that of masonry tanks would be to store the water in an ordinary bunded tank, with sides and bottom puddled, allowing for increased evaporation and other loss by enlarging the catchment area and storage capacity.

Existing small tanks might in some instances be improved and utilized, at no great expense, so

as to furnish a supply of usable, if not very pure, water protected from contamination. For this purpose the tank should be deepened, both it and a sufficient catchment area being well puddled, to render them watertight, and tank and area being surrounded by a good fence. An intercepting drain would also be required in most cases to prevent surface water, except that flowing from the prepared area, from entering the tank. The growth of aquatic plants would be beneficial, and should be encouraged in a tank of this kind if it be shallow.

Surface water collected in open tanks, may be sometimes employed; but it is very difficult to preserve open tanks from pollution when they are situated near villages. Surface water, even if collected from an unpolluted surface, must, at all events, contain a good deal of vegetable impurity, and it requires more careful filtration than rain-water collected on a prepared area. No fixed rules can be laid down for the calculation of the quantity of water obtainable by collection in an open tank from a surface which is not water-tight; it depends largely upon the porosity and inclination of the soil and the depth of the tank.

The supply which a well is capable of yielding may be estimated by pumping out a large quantity of, or all, the water, measuring the space from which the water has been removed, and observing the time which it takes to fill again. The cubic space (contents) may be calculated by multiplying the cross area (horizontal section) of the well by the depth of the water removed. Wells are generally circular or rectangular in cross section: the area of a circle is the square of its diameter multiplied by 0·7854, and of a rectangle its length multiplied by its breadth. Say, for instance, the water in a circular well, 3 feet in diameter, is found to be 12 feet deep. A mark is made to register the water level, and the

well is pumped dry. The time from the cessation of the pumping until it fills again to its former level is noted, and is, let us suppose, 5 hours. $3 \times 3 \times 0 \cdot 7854 = 7 \cdot 07$, the cross area of the well in square feet; this multiplied by $12 = 85$ cubic feet nearly, the contents of the well. Now 1 cubic foot $= 6 \cdot 24$ gallons; the contents are therefore 530 gallons; and, this quantity being yielded in five hours, the quantity which can be yielded in twenty-four hours will be $(5 : 24 :: 530 : x)$ 2,544 gallons. It must always be remembered that the yield of wells may vary greatly according to season and in different years.

The yield of a small stream may be ascertained by noting the time it takes to fill a vessel of known capacity, or by digging a pit of certain dimensions, turning the stream into it, and noting the time it takes to fill.

In the *distribution* of village water-supplies various improvements are feasible. The present ordinary plan of drawing water in private vessels should on no account be allowed, because impurities, including pathogenic organisms, may be thus conveyed to a well and distributed in its water. A public bucket with a rope and windlass, or a pump, is much safer. A still better arrangement would be to build a cistern at a convenient level, and have it filled once or several times daily, from the well or rain-reservoir or tank, by means of a pump or other mechanical elevator worked by public cattle, or by hand or water power or a windmill. When wind or water power is employed, provision should generally be made for the use of cattle when wind or water fail. The people could then obtain water from the cistern tap without any danger of polluting the source. For larger villages the water might be raised at the source, be carried into the village by pipes or an aqueduct and be distributed

to one or more public cisterns or fountains placed at convenient centres. A good public supply for villages could thus usually be managed at no great expense, and it would very largely contribute to the health and convenience of the inhabitants.

When a public supply is provided one of the village officials should have charge of it and be held responsible for its efficiency, and for the periodical cleansing and repairs of collecting surfaces, wells, storage tanks, filters, cisterns, etc.

Examination of Water.

Although an acquaintance with general and practical chemistry is necessary for well-qualified sanitary specialists, it is not to be expected that sanitary or medical officers in general, who are not experienced in chemical methods and manipulations, should be able to make an accurate quantitative analysis. Every Sanitary officer of superior grade should certainly know enough of chemistry to understand clearly the analytical methods employed, and it is necessary that all should at least be able to read a water analysis intelligently and to make a simple examination of the quality of a water. The object of the examination of water is to ascertain whether it contains dissolved minerals in such quantities as to be either inconvenient or actually deleterious, whether certain substances, in themselves harmless, are present which indicate past or recent pollution, and whether micro-organisms are to be found in it in such numbers or of such a nature as to render the water likely to carry disease.

The examination of a sample of water in a laboratory can enable the analyst or bacteriologist to pronounce an opinion only on the actual condition of the liquid supplied to him; he cannot guess at the possibilities of pollution which may exist.

A correct judgment of the safety of a water-supply can only be arrived at with a full knowledge of local conditions, with complete chemical analyses performed on several occasions and at different seasons, and with exact bacteriological examinations made at different times and seasons. The local Sanitary officer with his intimate knowledge of the possible sources of pollution, is in a position to supply most important facts on which the passing or condemnation of the water may rest.

Survey of Locality.—This consists in a careful survey of the source, whether mountain, catchment area, lake, river, well or tank; method of raising; storage; aqueducts; collecting or distributing channels; methods of purification; methods of distribution and the possibilities of contamination at any point.

Collection of Samples for Chemical Analysis.—Half a gallon of the water is required. It should be collected in perfectly clean bottles, fitted with glass stoppers, or at least new corks. The bottle must be repeatedly washed out with water from which a sample is to be taken. If filled from a river or tank, the sample should be taken from below the surface and at a little distance from the bank to avoid disturbed mud; if from a pipe, the tap should be allowed to run a little while first. The analysis should be made as soon after collection as possible, as important chemical changes may occur in the water, particularly in a warm place. If the sample has to be sent to a distance it should be packed in ice.

The following information should in each case be supplied to the analyst:—

(1) Source of water sample, tank, river, well, pipe, etc.

(2) Geological formation of ground as far as it is known.

(3) If from a well, give depth of well and water, diameter, construction, method of using, how much used, etc.

(4) Possibilities of pollution from drains, cesspools, surface washings, etc.

(5) If a surface water, give nature of collecting area and conditions of storage.

(6) State whether rainfall has been normal, in excess or in defect.

(7) Give the reasons for requiring the analysis.

The Physical Examination of water does not afford very reliable evidence. It is possible in this rough way to condemn a very bad water, but a highly dangerous one could easily be passed. The physical examination includes observation of the clearness, colour, taste and smell of the water, with a microscopic examination of the sediment. A tall jar or bottle of white glass should, if possible, be used for examining the clearness and colour of a water, the jar being placed in a good light upon a sheet of white paper, a considerable depth of water may be viewed by looking downwards through it. If the water be very turbid, the depth through which ordinary newspaper print can be read may be stated. It should also be noted if any distinguishable objects, such as bits of leaves or insects or small worms, alive or dead, are present. If there be any sediment, it should be observed whether it be compact or flocculent. If no colour or turbidity be apparent a second glass vessel of the same size filled with distilled or other very pure water may be placed beside the vessel containing the water under examination, and the two waters can then be compared.

The taste may be readily ascertained without swallowing any of the water. To detect the odour, if any, a clean wide-mouthed bottle should be half

filled with the water and shaken ; on then smelling the mouth of the bottle any odour will be evident. If no odour be perceptible, the bottle half full may be stoppered and set aside for twenty-four hours, when it should again be shaken and smelled, or, if it be desirable to complete the examination at once, gently warming the water, or the addition of a few drops of caustic potash solution to it, may cause the development of some odour.

If a water be clear and colourless, of a good lustre, free from objectionable taste or smell and without suspended matter, it may be judged good as far as this test is concerned, otherwise it must be regarded as suspicious. It must not be forgotten that a perfectly clear water may contain numerous invisible but harmful bacteria, and invisible dissolved minerals in injurious quantity.

The Microscopic Examination of sediment cannot be entered into in full detail here, and the recognition of the various objects which may be seen implies considerable experience and skill. The most important microscopic finds are objects which are not normally present in natural waters and which, therefore, indicate the possibility of harmful contamination. Such are spores and mycelia of fungi which will not grow in a water free from phosphates. Phosphates in a water generally means sewage pollution. Cotton fibres, hairs, epithelial cells, starch grains and ova of worms, all point to contamination with human refuse.

The Chemical Examination of water.— The qualitative analysis of a water is made to find out what substances are present in solution, the quantitative to determine the exact proportions of each. The latter requires considerable experience and a well equipped laboratory, the former may be

carried out by any sanitary inspector with a few stock chemicals, some test tubes, and a spirit lamp, and afford information of much value.

Qualitative Analysis.—The following table exhibits the simplest reactions which can be noted:—

Reaction.	Test with red and blue litmus papers.	Acid turns the blue red, the alkali turns the red blue.
Chlorides ...	Add dilute nitric acid and silver nitrate solution. A white precipitate.	1·4 parts per 100,000 give a haze. 6·0 parts per 100,000 give turbidity. 14·0 parts per 100,000 give a precipitate.
Sulphates ..	Add dilute hydrochloric acid and barium chloride. A white precipitate.	4·0 parts per 100,000 give a haze. 8·0 parts per 100,000 give a precipitate.
Calcium (lime)	Add ammonium oxalate and boil. A white precipitate.	9·0 parts per 100,000 give a turbidity. 16·0 parts per 100,000 give a precipitate.
Ammonia	Add Nessler's solution. Yellow or brown colour or precipitate.	Much ammonia if colour is marked.
Nitrous acid (nitrites).	Add metaphenylamine, diamine and dilute sulphuric acid. Yellow colour on standing.	1 part in 10,000,000 gives a yellow colour in ½ hour.
Nitric acid (nitrates).	Add brucine solution and shake. Then pour strong sulphuric acid down the side of the tube so as to form a layer at the bottom. A pink and yellow zone is formed where the liquids meet.	Pink zone obtained when 0·7 parts per 100,000 are present. This test is not reliable if nitrites are present.

Inferences to be drawn from Qualitative tests.—The deductions which can be made from the information supplied by the physical and microscopical

examinations have been touched on under those headings. As regards the chemical tests:—a strongly acid or alkaline reaction should condemn a water unless the cause can be proved harmless by more elaborate experiments.

Chlorides are contained more or less in all natural waters. If the quantity be large, it is derived either from strata rich in sodium or calcium chloride or from sandy soil connected with the sea, or from organic pollution.

Strata containing sodium chloride often contain sodium carbonate also which gives an alkaline reaction to the water. A water containing calcium chloride will give a precipitate on boiling with ammonium oxalate. If at the same time there are no nitrites or nitrates and little ammonia, the presence of chlorides does not point to organic pollution.

Chlorides due to infiltration of sea water are accompanied by much magnesia, but little nitric acid.

If due to sewage contamination, nitrous and nitric acids and ammonia will also be found in considerable quantities. Sulphates in large quantities with little evidence of organic pollution indicate the presence of sodium or magnesium sulphate from the soil. In this case a high percentage of chlorides is usually found also.

Sulphates in combination with nitrates and ammonia point to organic pollution. Sulphates in quantity sufficient to cause turbidity in the test solution should condemn a water.

Calcium is a measure of the hardness of water and has no connection with organic pollution. Large quantities render a water unfit for domestic or industrial purposes. Ammonia is found in minute quantities in most waters. It is usually derived

from the decomposition of nitrogenous organic matter, and if present in sufficient amount to give a marked colour to the qualitative test, the water should be condemned.

Nitrites are also products of the decomposition of organic matter and, if present, it is judged that the contamination is recent and the water is condemned. Nitrites are very rarely harmless salts dissolved from the strata through which the water has passed.

Nitrates are the last stage in the decomposition of organic matter. If accompanied by much chloride and ammonia, the evidence suggests a fairly recent organic contamination, and the water should be condemned; but, if the ammonia figure is low, nitrates alone may have been derived from the soil, and indicate organic decomposition at a long passed date and not present danger, and the water need not be considered unfit.

When all the available data are contemplated, an opinion can be formed of the suitability of the water for drinking, domestic or industrial use. Put shortly, any evidence of recent organic pollution should condemn a water for drinking purposes. Very hard waters are also to be deemed unfit for domestic or industrial purposes.

The Quantitative Analysis of Water.—This, as previously mentioned, can only be conducted by a skilled chemist, and a detailed description of the methods employed would be out of place in this manual. A clear understanding of the information to be expected from a complete chemical analysis and a discerning interpretation of the figures arrived at should be part of the stock of knowledge of the sanitary official, whether he be an expert analyst himself or not. For this reason the table below is inserted with the following commentary on its items.

In a good water the various constituents should not exceed these proportions :—

Total solids ...	Should be under 10 parts per 100,000. (a) *fixed*: salts of metals, silica. (b) *volatile* (organic matter, ammonia, nitrites, nitrates) should be under 1·5 parts per 100,000.
Chlorine	1·5—3 parts per 100,000.
Hardness	*Total*: 30 parts per 100,000 or 21 degrees (Clark's scale). A good soft water contains less than 5 parts per 100,000 *Permanent hardness* under 3 parts per 100,000.
Nitrates	Less than 1·5 parts of nitric acid per 100,000.
Nitrites	*Nil.*
Free ammonia ...	·002—·005 parts per 100,000.
Albumenoid ammonia	·005—·01 parts per 100,000.
Sulphates	Under 3 parts per 100,000.
Phosphates	A trace.
Total combined nitrogen (nitrates, nitrites, ammonia).	Under ·4 parts per 100,000.
Oxidisable matter (oxygen absorbed in 15 minutes at 80°F from potassium permanganate).	·05—·1 parts per 100,000.

A short account must now be given of the meaning of each of the above determinations and the inferences which may be drawn from it, when considered singly or in conjunction with other determinations.

The *total solids* are estimated by weighing the residue left after the evaporation of a known volume of the water at a low temperature. They comprise all the solid matter contained in the water, suspended and dissolved, organic and mineral. The mineral matter is comparatively heavy and forms the largest part of the solids. On heating the

deposit the organic matter is burnt off and nitrates, ammoniacal salts, combined carbonic acid and water are volatilised, leaving the fixed solids behind. A high proportion of volatile solids means an excess of organic matter.

Chlorine in excess may be derived from the strata. Deep well water often shows a high chlorine figure and is hard in consequence, but not dangerous, if, at the same time, the ammonias and volatile solids are low. Similarly, if derived from the percolation of sea water, the figures indicating organic pollution will be low.

If the excess of chlorine is due to organic pollution, particularly decomposed urine, the fact will be shown by high figures for the volatile solids and ammonias.

Total hardness is no indication of the organic pollution of a water nor does it denote its wholesomeness or otherwise, since a water may be rendered hard by harmless carbonic acid, chlorides and carbonates, as well as by sulphates which may have unpleasant effects. Hard water, as mentioned before, is not well suited for washing, cooking or industrial purposes.

When water is boiled, carbonic acid, which holds in solution several salts, is driven off, and these salts are deposited on the sides of the vessel, and, in the case of steam boilers, form incrustations, which are bad conductors of heat and add greatly to the expense of firing. The salts rendered soluble by carbon dioxide are chiefly the carbonates of calcium and magnesium.

Permanent hardness is the name applied to the condition of a water after boiling. Salts which do not owe their solubility to combination with carbon dioxide, remain in solution after boiling, and it is to these that the permanent hardness of a water is due.

They are sulphates, chlorides and nitrates of calcium and magnesium with some iron and oxide of aluminium, and, if present in any quantity, render a water objectionable for most purposes. The hardness lost by the expulsion of carbon dioxide in boiling, which causes the deposition of calcium carbonate, is termed the *temporary hardness*. The quantity of organic matter in a water is regarded as a measure of its purity and freedom from danger. It is not the dead organic matter itself which is dangerous, nor the various products resulting from its decomposition, but the accompanying micro-organisms, whose presence cannot be detected by chemical methods. Organic matter of vegetable origin is not associated with noxious organisms, but organic matter of animal origin is. The ultimate products of the decomposition of organic matter are the same whether it is of vegetable or of animal origin. So a chemical analysis here fails to gauge accurately the degree of danger in an organically polluted water. There is no single process for the estimation of organic matter; an analysis aims at a determination of the amounts of the final products of its resolution, namely, carbonic acid, ammonia, nitrites and nitrates.

Free Ammonia represents the ammonia in combination with mineral or organic acids, and a certain quantity which may be derived from the decomposition of urea and other organic substances. If in excess of the accepted figure and accompanied by high chlorine and nitrate figures the water must be condemned.

Albumenoid Ammonia.—The free ammonia is not a measure of the total quantity of nitrogenous matter in the water, but only of the easily decomposable portion. By a process of destructive distillation more of the nitrogenous matter can be broken up and its quantity estimated in terms of

ammonia. This is called albumenoid ammonia and it represents about one-tenth of the nitrogenous matter present. A large quantity of albumenoid ammonia and little free ammonia points to organic matter of vegetable origin, and, other things being equal, need not alone cause the condemnation of a water. If both ammonias are high, the water cannot be passed.

Nitrites mark the first stage in the oxidation of nitrogenous organic matter and the next stage in its natural purification, the former being the production of ammonia. Nitrites in water are evidence of very recent animal pollution, because they are unstable salts and quickly become further oxided into nitrates and also because the decomposition of vegetable matter does not yield much nitrogen. Growing plants and algæ in water rapidly remove nitrites and nitrates.

Nitrates are the final stage in the oxidation of nitrogenous organic matter and represent pollution of long standing which has been completely oxidised and rendered harmless. If present in large quantity with free ammonia and other indications of recent pollution, a water must be condemned: even without evidence of recent pollution a high nitrate figure should cause a suspicion that the water is mixed with purified sewage. At any time the machinery of purification, whether natural or artificial, may break down, and allow crude sewage to gain access to the water with disastrous results. In India nitrates in water may be derived from nitre deposits existing in the soil. In such a case the water may be usable, though hard. Waters containing nitrates are plumbo-solvent. Surface waters in Madras contain little nitrate but usually plenty of free and albumenoid ammonia. Deep waters, on the other hand, contain much nitrate but little ammonia. This shows that the nitrifying organisms

which break down and oxidise organic matter, either have not had time to do their work of purification before the collection of the water, or that their action is inhibited by heat on the actual surface of the land. Later on when the water soaks into the soil, the nitrifying organisms do their work, and nitrates are found in the deep waters.

Sulphates in water are chiefly derived from strata: a very small amount is due to the oxidation of the sulphur in organic matter.

Phosphates indicate organic pollution, particularly with urine.

From the above it will be seen that a water can be condemned or passed on no single chemical test; all the data available must be passed in review, and the suggestions of one estimation weighed against the facts of another, and the whole considered in relation to the origin and possibilities of pollution of the water. A much better notion of the composition of water is gained by comparing the figures of periodical analyses, when deviations from the average will be readily apparent. In such a way a slight rise in, say, the free ammonia, which in a single analysis might have passed muster, would attract attention, and a grave source of pollution might be discovered to account for it, which would otherwise have escaped notice.

The chemical analysis of water, however, has its limitations: it can determine the amount of added impurity and declare that a water is dangerous, but it cannot show that it is safe. Though chemically pure, a water may contain pathogenic organisms in sufficient number to start an epidemic.

The Bacteriological Examination of Water.—The chemical examination must be supplemented by bacteriological examination, made with the object of ascertaining the number, and, if

possible, the species of bacteria present; that is to say it is both quantitative and qualitative. A bacteriological examination is undertaken to test the efficiency of filter beds, or to detect the pollution of water by organic matter of animal origin, *i.e.*, excreta or sewage.

Owing to the enormous number of saprophytic bacteria often present it is frequently impracticable to isolate pathogenic organisms from a water, so the bacteriological test as a rule resolves itself into an enumeration of the number of organisms present in a given volume of water, irrespective of their nature, on the principle that the more bacteria there are, the more likely is it that some of them will be of harmful species. No definite line can be drawn as to the number of organisms permissible, but to have some sort of standard it may be said that the number should not exceed 100 per cubic centimetre in filtered water. Far more importance must be attached to the species present than to the mere number. The methods employed for the detection of these organisms cannot be entered into here: they are beyond the range at present of those for whom this book is intended. A water cannot be sent to a distant laboratory for bacteriological examination without special precautions. It is best that the work be done on the spot; if this be not possible the sample must be put at once in ice in a specially constructed box. The reason is that the bacterial contents of a sample may enormously increase in a few hours at air temperature and if the examination be delayed an entirely false idea of the water may be entertained. For instance in a sample examined at the time of collection Frankland found—

In the morning	7	bacteria per cubic centimetre.
At the end of the day .	21	
On the third day . .	495,000	

of bacteria in a water sample varies in the opinion of different authorities, the reason being that results are so seldom comparable. The slightest variation in the composition of the medium, temperature of incubation, and a score of other factors has so great an influence on the development of water bacteria that the enumerations of different workers in separate places have no common basis of comparison.

The only sound procedure is to estimate the organisms in a water on numerous occasions under exactly similar conditions so that a standard may be obtained for that particular water, and deviations from it can then be recognised, just as a chemical standard can be established for a particular water.

Very little work in this direction has yet been possible in India.

Qualitative Bacteriological Examination.—It must be understood that a water is very seldom examined to identify the actual causative organisms of disease, for those are few in number compared with the myriads of common water organisms always present and correspondingly difficult to isolate. The ordinary bacteriological examination is directed to the identification of organisms not ordinarily found in natural waters, but always present in excreta, the presumption being that, if common fœcal bacteria can obtain access to the water, pathogenic organisms can also find their way in.

It is probable that the bacteriological standards of purity which are insisted on in England cannot be quite the same in India where the conditions are so different. Few Indian waters, even those from protected sources, would pass English tests, yet it does not appear that the consumers suffer from the use of them in the way of epidemic disease. A great deal of the pollution of Indian waters is

caused by animal excreta being washed from the catchment area into the supply in times of heavy rain. In England there is comparatively little pollution of surfaces by animals, and chemical or bacteriological evidence of organic pollution generally means that sewage, which is largely a human product, has entered the supply. Human and animal fœcal bacteria are not necessarily the same, either in number, species or nature.

Local standards must be accumulated for Indian supplies, and with present knowledge and experience an Indian water cannot be accurately or fairly judged on general principles. In the Madras Presidency waters are derived chiefly from disintegrating gneiss, laterite, sandy and alluvial soils, which are all very porous and permit the passage of impurities easily. There is little clay soil or chalk deposit. After prolonged dry weather, a heavy shower will increase the number of fœcal organisms in a shallow well in porous soil. Bacillus coli communis, a frequent and easily recognised fœcal organism, appears in well water after the first rains, but tends to disappear if heavy rain continues. Similarly much heavy rain improves the character of the sub-soil water.

Storage of water in open tanks, where the sun can exert its full effect on it, has been shown in England to have a most marked purifying effect: in India the effect is no less marked and much more rapid.

A characteristic of fresh fœcal matter and of water polluted with it is a great variety of organisms. Some of these have little vitality in water and soon die out. Others are remarkably resistant and can be identified after a great lapse of time. There are many intermediate forms as well. Bacillus coli communis is not a resistant organism and is easily killed by sunlight and storage. If it is found in a

water which has been stored, recent contamination is to be suspected. Bacillus cloacæ is a very resistant organism, and, if it alone can be found, pollution of distant date is indicated.

Bacillus lactis ærogenes is not numerous in freshly polluted waters, but it tends to increase as time goes on, so if it is found in large numbers, it is evidence that pollution has occurred but that purification is fast proceeding.

In dry weather a shallow well may contain nothing but resistant organisms, indicating long past pollution. A shower may cause numerous bacilli coli to appear. These do not seem to be derived from the immediate soakage of surface washings, so much as from the deeper and moist parts of the soi to which they had gained access on a former occasion, If bacillus coli can exist thus and suddenly find entrance into a well, it is presumptive evidence that the organisms of cholera and typhoid can do likewise.

Another fœcal organism which in England is considered evidence of pollution is bacillus sporogenes enteritidis. This is a very resistant organism and its identification gives no date to the pollution of the water.

In the Madras Presidency waters are bacteriologically at their worst in July, August and September, which corresponds closely with the cholera and dysentery season.

They tend to improve in the next three months, and, roughly speaking, are at their best in January, February and March, which is the season with the lowest general death-rate.

The following tentative standards for the Madras Presidency have been suggested by Major Clemesha, I.M.S. (1909) :—

Good lake water.—Less than 100 colonies per cc. on agar at 37° C.

No lactose fermenting organisms in 20 cc.

No non-resistant organisms in 50 cc. Bacillus lactis ærogenes plentiful.

Usable lake water.—Less than 200 colonies per cc. in agar at 37° C.

No lactose fermenting organisms in 5 cc.

No non-resistant organisms in 20 cc. Bacillus lactis ærogenes, very plentiful.

Unusable lake water.—Bacillus coli found in 1 cc.

Fœcal organisms present in proportions similar to those of fresh.

Bacillus lactis ærogenes, few or absent.

Good river water.—Less than 100 colonies per cc.

No bacillus coli in 50 cc.

Fœcal organisms, not more than 1 in 10 cc.

Usable river water.—Less than 300 colonies per cc.

No bacillus coli in 20 cc.

Fœcal organisms, not more than 1 in 1 cc.

Unusable river water.—800 colonies per cc.

Bacillus coli 1 in 5 cc.

Lactose fermenting organisms 10 per cc.

Numerous varieties of fœcal organisms.

Deep waters.—Less than 50 colonies per cc.

No bacillus coli in 100 cc.

No fœcal bacilli in 20 cc.

All filtered waters must belong bacteriologically to the class "good." If not, the filter is not doing its work properly. Regular bacteriological examinations should be made of the effluent from filters to check their work. It frequently happens that a filter effluent is much purer bacteriologically than water drawn from a tap in the town. This is due to bacteria being added to the water from the slime and silt which collects in the distribution pipes.

Ice should be manufactured from the purest water available and a factory should have its own filters if the public supply is open to suspicion. Bacteria are not destroyed by the temperature of frozen water, they merely cease to multiply and when the ice is melted their vitality is restored and they grow with vigour.

The manufacture of *aerated waters* requires the strictest supervision, not only as regards the water put into the bottles, but as regards the premises and arrangements for washing the bottles. Only the purest water should be used, since neither the pressure nor the presence of dissolved carbon dioxide gas has much adverse influence on the vitality of bacteria, at any rate during the time within which the aerated waters are usually consumed.

CHAPTER IV.

AIR.

Composition of Air.

The atmosphere or air which surrounds the earth is a mixture of gases, consisting of 79 per cent. of nitrogen and 21 per cent. of oxygen by volume. It also contains normally a small amount (0·03 per cent.)* of carbon dioxide gas, traces of ammonia and nitric acid, and a variable quantity of water in the form of vapour. The air gradually diminishes in density as we ascend from the surface of the earth, and it does not appear to extend beyond 200 miles from the surface. The quantity of watery vapour which air is capable of containing varies with temperature and barometric pressure. At the average pressure at sea level and within the ranges of temperature met with in Madras, 1 cubic foot of air is capable of holding from 6 grains, at lowest temperature, to 12 grains, at highest, of watery vapour (14 to 28 grams per cubic metre). The amount of moisture which is most agreeable and generally best for health is about 60 per cent. of the quantity required for saturation of the air. This subject has to be further alluded to in the section on climate.

Nitrogen, of which the air is principally composed, possesses no active properties. Oxygen is essential for the support of animal life. Its main function is to oxidize (a process chemically analogous

* The air in towns contains more nearly ·04 per cent. of carbon dioxide.

to burning) food substances which have been absorbed, and thus to evolve animal energy and heat. The proportion of oxygen in air varies a little in different places, being slightly less in towns than in the country. Traces of a condensed and very active form of oxygen, termed ozone, exist in very pure air, but not in the air of crowded places.

Carbon dioxide (carbonic acid gas) is given out abundantly in the respiration of animals, and to a less degree of plants; and it is absorbed by the green leaves of plants and decomposed by them under the influence of light, the carbon being retained and oxygen liberated. The proportion of carbon dioxide varies to a small extent in pure air, but in crowded places it is considerably increased. This gas is evolved from lime-kilns, from the combustion of wood, coal, and organic matter generally, the chief source perhaps being decaying organic matter mostly vegetable in origin. Men have been suffocated by it when incautiously sleeping near lime-kilns, or approaching places where large quantities of gunpowder had just been exploded in blasting, or after explosions in coal mines, or in descending into old wells and holds of ships.* Air containing much more than 5 per cent. of carbon dioxide will not support life, and 1·5 per cent. in air will cause headache.

IMPURITIES OF AIR.

Natural air, like natural water, is never pure. It is being constantly polluted, but it is also constantly being purified by various agencies. Air is rendered impure by respiration, emanations from the skin and excretions of animals, by putrefaction of

* A lighted candle may be used to test the purity of the air in such places before men enter them. If the flame be extinguished, it is certain that the air will not support life.

organic substances, by combustion, by exhalations from the soil, and by dust consisting of various mineral and organic materials. It is purified by the diffusion of gases, dispersion of impurities by wind, the action of plants, oxidation, rain and dew, and gravitation which causes the subsidence of dust in still air. The impurities of air may be considered in two classes: (1) gaseous, analogous to dissolved impurities in water; (2) suspended, like suspended impurities in water.

Of *gaseous impurities* excess of carbon dioxide has already been mentioned. Gases which are chemically poisonous or irritant are sometimes evolved from factories, such as brick-kilns and cement, alkali, smelting and various chemical works. Fetid organic gases, often of ammoniacal nature, emitted from putrefying materials, may exert poisonous effects. Gaseous impurities in air are rapidly diluted and rendered harmless by diffusion and dispersing currents of air. Those which are soluble in water are also carried down by rain, and complex organic gases are gradually oxidised or decomposed into simple compounds.

Suspended solid impurities are everywhere present in air, and are, as a rule, much more dangerous, as well as more widely diffused, than gaseous impurities. Mountain air and sea air are almost entirely free from them. They may be mineral or organic. Mineral, or inorganic, suspended substances consist of dust raised by the wind or thrown up by volcanoes, minute crystals of common salt derived from sea spray, carbon from smoke, and particles of metals or other materials arising from certain trade processes. Dust has been known to be transported by wind for hundreds of miles, and it is believed that the dust thrown up in the great eruption of Krakatoa in 1883 was diffused through the entire atmosphere of the earth.

Mineral dust in air is apt to cause diseases of the air passages and lungs (bronchitis, asthma, emphysema, and destructive lung diseases), and in trades, such as mining and grinding metal implements, where much dust is produced, the average lifetime of workmen is shortened and lung diseases are more than usually prevalent. This is particularly the case when the particles of dust are hard and angular. The dust arising in certain trades may be chemically poisonous, for instance white-lead from paint-grinding, arsenic from certain paints, antimony from printing type, etc.

Organic suspended matter in the air may be dead or living. The former consists of vegetable fibres and fragments, bits of insects and other animal fragments, and dried excrement. It can do no particular harm. The latter includes bacteria, fungus spores and pollen grains. Aerial bacteria are mostly saprophytic. The air is not the natural habitat of any living organisms since they can obtain no nourishment there. Still they are always present, being most numerous in dirty places and during dry weather.* They are particularly numerous in places where the soil is foul, where men or other animals are congregated, and where ventilation is bad. They subside rapidly in still air by gravitation. Very few exist in mountain or sea air compared with the number found in the air of plains and of towns. Pathogenic bacteria may at times be transported from place to place by the air, and disease may be thus spread.

Such organisms are drawn into the lungs with the inspired air, and thus the specific organisms of some diseases may enter the body; or they may

* A recent calculation goes to show that a man may take more bacteria into his stomach in drinking ¼ litre of milk than he is likely to inspire into his lungs during a lifetime of 70 years.

be arrested in the nose or throat and be swallowed. The rapid occurrence of fermentation or putrefaction (due to the development of microbes) in organic substances exposed to the air, and the growth of moulds (fungi) on such substances, are evidence of the omnipresence of spores of these organisms in ordinary air.

Flying insects may act as mechanical carriers of disease. Contagious ophthalmia, anthrax, small-pox, cholera and typhoid have all on occasions been attributed to this agency.

Impurities added to air by respiration.—

	Inspired air. Vols. per cent.	Expired air. Vols. per cent.
Oxygen	20·96	16·40
Nitrogen	79·0	79·19
Carbon dioxide ...	·04	4·41
Aqueous vapour ...	Variable.	Saturated.
Organic matter ...	*Nil.*	Considerable quantity.

Air therefore loses during respiration about 4 volumes per cent. of oxygen and has added to it about 4 volumes per cent. of carbon dioxide, aqueous vapour and organic matter.

It has been calculated from a number of observations that an average adult man breaths 18 times a minute when at rest and expires 22 cubic inches each time of 330 cubic feet in 24 hours. Assuming that the expired air contains 4·4 per cent. carbon dioxide, he evolves $\frac{330 \times 4{\cdot}4}{100} = 14{\cdot}25$ cubic feet of carbon dioxide in 24 hours or 0·6 cubic foot in one hour. The quantity evolved depends on the body weight: small men and women evolve less than big men, but children, weight for weight, evolve twice as much as adults. Exercise also largely increases the output. The above is the standard usually adopted for a mixed community.

Little is known about the *organic matter* in expired air, except that it is nitrogenous and quickly putrefies. It can be noticed by the smell when the carbon dioxide in the air of a room has been raised by respiration to ·08 per cent.

The discomfort produced by an overcrowded and ill-ventilated room is probably chiefly due to excessive temperature, increased humidity, and unpleasant odours. The harmful effect of breathing vitiated air is more probably due to excess of carbon dioxide and want of oxygen than to poisonous organic matter. The immediate effect of breathing air rendered foul in this way is headache, sickness and loss of appetite : if it is habitually breathed, general deterioration of health, and increased liability to disease, especially to phthisis are engendered. There can be no doubt that the habitual breathing of impure air affects the health, and, in addition, retards recovery from disease.

In crowded localities the impurity of the air arises from defective ventilation and the imperfect removal of refuse and excreta. If ventilation be good, and refuse is not allowed to accumulate, even a dense and poor locality need not have a high death-rate. Animals kept in stables in towns suffer in health in the same way as human beings from impure air. The total effect of an impure atmosphere cannot be doubted, but it is difficult to assign a definite action to any one impurity.

Diseases due to Impure Air.

Diseases which are communicable through air are capable of being so communicated at very various distances, and some infections are transmitted much more readily than others ; it appears as though many disease germs were incapable of living long in pure air and that the term of their vitality in air were

limited for each disease. It is probable, however, that under favourable circumstances the spores of some of these organisms may retain their vitality in air for a great length of time. Infections which are supposed to be transmissible through the medium of the air are those of the eruptive fevers, such as scarlatina, small-pox, measles and dengue, whooping cough and influenza. Those of cholera and enteric fever are less readily conveyed by air.

It is not often easy to ascertain the hurtful impurity in unwholesome air, for such air generally contains many kinds of impurity mingled. Thus air polluted by effluvia of decomposing animal matter often causes nausea or vomiting, loss of appetite, fever, with diarrhœa and sometimes dysentery; but it is not generally certain whether these effects are due to the chemically poisonous gases evolved, or to certain microbes contained in the air, though the balance of opinion and of evidence is in favour of the latter cause.

Purification of Air.

It is manifestly of the greatest importance that breathing air should be as pure as possible. The only practical methods of securing the purity of air, are to regularly remove all refuse which can contaminate it, to facilitate the dispersion of such impurities as have gained access to it and, at the same time, to provide a constant supply of fresh unpolluted air. This is the object of ventilation.

Subsidiary means are sometimes resorted to for the sake of destroying or getting rid of certain impurities: thus roads are watered to prevent dust in towns, wet grinding has been largely substituted for dry grinding in factories, smoke-consuming furnaces are used to destroy smoke and noxious gases, the latter are sometimes condensed or dispersed

high in the air by means of lofty chimneys, disease contagia are destroyed by chemical means or by heat; but ventilation is practically the sole means of purification for ordinary purposes of the air of dwelling houses.

Cleanliness is an important aid to ventilation in preserving the purity of air in houses. Microbes are comparatively few in the air of clean and of new rooms, while they abound in that of dirty and old rooms.

In regard to ventilation we have to consider—firstly, the standard of purity which it is necessary to maintain in dwelling rooms, and secondly, the means by which that standard may be maintained.

It is obvious that the air of inhabited places cannot be as pure as the external air; but it is assumed, and indeed it has been ascertained by observation, that the sense of smell is generally a safe guide as to the purity of such air, and that if it does not differ perceptibly from the outside air, the amount of impurity is not sufficient to influence the health of the inhabitants. Organic matter and fetid gases are the substances which affect the sense of smell, but carbon dioxide is generally taken as an indication of the amount of contamination of the air of inhabited places, because the quantity of this gas in air is easily determined by chemical tests.

Air, as we have seen, normally contains ·04 per cent. of carbon dioxide. The maximum amount allowed to be added to this by respiration is empirically fixed at ·02 per cent. carbon dioxide. Adding the two we get ·06 per cent. and it is the object in ventilation to keep the carbon dioxide down to this level.

To find the quantity of air required by each person per hour, divide the amount of carbon dioxide exhaled by one person per hour (0·6 cubic foot) by

the limit of admissible impurity stated in cubic feet ($\cdot02$ per cent.$=\cdot0002$ in 1 cubic foot). The result is $\frac{0\cdot6}{\cdot0002}=3{,}000$ cubic feet, which is the amount of fresh air required per head of a mixed assembly in order that the impurities added by respiration may not rise above the limit fixed.

A man doing hard work might exhale 2 cubic feet of carbon dioxide per hour instead of 0·6. In this case he would require $\frac{2\cdot0}{\cdot0002}=10{,}000$ cubic feet of fresh air per hour.

Experiments show that more fresh air is required among the sick than among the healthy. Therefore not less than 4,000 cubic feet per head should be supplied in hospitals. It is a good rule to treat all sick persons as much in the open air as possible. Nothing is more likely to retard recovery or even to cause death, than to confine a sick man to the smallest, darkest and, therefore, dirtiest room in a house. It is usual in Madras amongst the untaught multitude to thrust any one who falls sick into a room which has no window and, consequently, no ventilation to speak of, and, if the disease be an infectious one, all who enter are obliged to breathe the concentrated exhalations from his lungs and skin, and, not unfrequently, from his excreta also, and thereby run much greater risks than would be the case in a well ventilated apartment.

VENTILATION.

Natural Ventilation.—It is an important requisite of good ventilation that the quantity of air required should be supplied without any very perceptible draught; for this purpose considerable cubic space is needed. It has been found in practice that the air of a room cannot be changed oftener than from three to four times in an hour without

creating much draught. The best results in the practical ventilation of public buildings (schools) have been obtained with an air space of 1,000 cubic feet per head; a larger space appears to encourage stagnation of air.

A large space is also useful, because, in case of temporary failure of wind or other means of ventilation, it affords a reserve of air and becomes vitiated less rapidly than a small space.

Large rooms are more easily ventilated than small rooms, consequently in small rooms more numerous ventilating apertures and a larger cubic space per head should, if possible, be allowed.

A greater height than 12 or 14 feet is not generally found useful for the purposes of ventilation, and it is a good general rule that the superficial space (floor area) ought, in square measurement, to be not less than one-twelfth of the cubic space, in cube measurement. Height is however of great service in keeping rooms cool in hot countries when the roof is strongly heated by the sun. Large superficial space is very useful in isolating individuals, allowing the rapid diffusion of the exhalations from their lungs and skin. In hospitals it is obviously of particular advantage. We have seen that efficient ventilation cannot be provided without draught in a room affording less than 500 cubic feet per head of space, which must, therefore, be regarded as, in all cases, the smallest amount of cubic space which is compatible with purity of air in a dwelling-room. One-twelfth of 500 is 41·7, and, in round numbers, 40 square feet per head must be regarded as the smallest superficial space allowable. One hundred square feet is a good allowance, and less than this should not be permitted in hospitals.

The smallest effective size of ventilating openings is the next point to be considered. The size of the inlet openings should be at least 36 square

inches (6×6 inches) per head, and the outlet should be as large. This will allow 3,000 cubic feet per head per hour to enter and leave, supposing the air to flow through the openings at a rate of nearly $3\frac{1}{2}$ feet per second, at which rate its motion is only slightly perceptible. It is impossible to obtain this constant rate of flow, except when artificial means of ventilation are employed; but under ordinary circumstances of climate in Southern India, when it is cold enough to have doors and windows closed, this minimum rate of ventilation will be secured by properly constructed apertures of the dimensions stated; and, if doors and windows are closed to exclude hot air in the day time, larger openings covered with wet grass mats should be provided.

It is necessary for good ventilation that the pure air which enters should be well distributed. If there be few openings and the air enters at considerable speed, most of it may pass in a stream from one opening to another without spreading throughout the room. To prevent this many openings for ventilation are generally required in large rooms, or the in-coming air may be directed in such a way that it shall spread. To effect this purpose, a simple contrivance is to direct the entering air obliquely upwards by louvres or an inclined board at the ingress. Another plan is to allow air to pass in through vertical tubes (Tobin's tubes), 4 feet or more high, fixed in the corners or along the walls of the room. Direction upwards of the in-coming current of air, besides serving to disperse it, also protects the inmates from draughts.

The difference in temperature of the air within a building, and of that outside, is an important factor in ventilation. In cold climates the air inside is nearly always warmer than the outer air; and as the air within expands with heat, it becomes specifically lighter and ascends, being replaced by colder air

which passes inwards most rapidly by the lowest openings in the building. The greater the difference in temperature inside and outside the building, and the higher the building, the more rapid is the ascending current. For this reason, in cold climates, it is generally practicable to provide some openings which serve constantly for the ingress, and others which serve constantly for the egress of air.

In hot climates, however, the case is different, the outside air being sometimes colder and sometimes warmer than that inside, while sometimes the outside and inside temperature are equal. Thus upward, downward or no currents may be produced by temperature, and as the difference of temperature is never very great, the currents from this cause are never strong. We have then usually in India to depend upon the wind for natural ventilation, and it is manifest that unless revolving cowls or artificial ventilation be resorted to, the same openings must serve sometimes for ingress and sometimes for egress of air. The most simple and direct methods for ventilation are therefore the best, and tubes, shafts, and valves should, as a rule, be dispensed with. In single-storied buildings, with low roofs, ridge-ventilation may be all that is required.

In higher buildings ventilators may be placed in doors or windows at a height of 6 or 7 feet, or separate ventilators may be placed in the walls. Direct ventilation at the ground level through the walls is generally to be deprecated, as foul air is more likely to be found near the ground than higher. In the huts of the poor, and even in the houses of the wealthy, there is often an insufficiency of windows for good ventilation even when they are open. Where this is found to be the case ventilators can, as a rule, be inserted at a very small cost. Tiled roofs, even when no ridge-ventilation is provided, generally afford a free passage to air.

When, as occasionally happens, the wind fails entirely and there is no difference of temperature outside and in to cause any movement of air, natural ventilation is impossible, and the air can be but slowly purified by the diffusion of gaseous and the subsidence of suspended impurities. In such circumstances doors and windows should be fully opened and people should, if possible, remain in the open air. The creation of movement by artificial means as fans and punkahs, is particularly valuable under such circumstances.

Ventilation by shafts with revolving or fixed tops of various kinds is only efficient so long as the wind is fairly strong, that is when they are least wanted ; but when the wind fails they cease to act as intended, and are less useful than ordinary direct openings. Such contrivances are therefore, as a rule, to be avoided for house ventilation. The proper ventilation of houses in Indian bazaars is often still further obstructed by the narrowness of the streets, and the available width is sometimes even further reduced by tatty structures which project over the roadway. The air in such places is always more or less stagnant and evil smelling, being undisturbed by the perflation of the wind, unless the latter be very high.

In sunny weather considerable movement of the air in a room may be secured by a large vertical metal tube inserted through the roof, the upper part of which, some six feet high, projects into the air and is painted black. The blackened metal gets very hot in the sun and warms up the air within it and so creates an upward current.

The Chinese who build their houses high and their streets so narrow that no wheeled traffic is possible, secure ventilation of the lower rooms by large matting wind-sails on the roofs with funnel shaped mouths turned towards the wind. These

convey fresh air down to the lower regions in the same way as air is supplied to the lower parts of a large ship at sea. The method might be usefully adopted in parts of some Indian towns.

It should not be forgotten that cattle, goats and horses require as much as or more fresh air than human beings in proportion to their size, and that if they be confined in closed rooms and sheds where there is not sufficient cubic space, they suffer in health equally with human beings. Cattle should never, when it can be avoided, be stalled in one of the rooms of a house, as is not unfrequently done, or even in a verandah. Private cattle sheds should be open on three sides to the air and should be situated well away from the house in an open yard. In crowded towns private cattle yards are not to be encouraged; it is far better for the local authority to establish a public cattle yard where the animals can be kept under sanitary conditions and to lease out stalls to private owners.

An important point in connection with the ventilation of houses is the provision of apertures for the escape of smoke and vitiated air arising from wood and charcoal fires in sleeping rooms. Charcoal in particular during its combustion forms a quantity of a poisonous gas called carbon monoxide, 1 per cent. of which in the air is rapidly fatal to human beings, while 0·1 per cent. gives rise to serious symptoms. Numbers of persons annually meet their death by going to sleep in an unventilated room in which a charcoal fire has been lit for warmth.

It is generally found to be the case that the inhabitants of leaf and mat huts, which allow the free passage of air at all times, enjoy better health, even though they may be living in extreme poverty, than those who occupy more solid, but less well ventilated structures.

Artificial Ventilation.—Artificial ventilation may be carried out by (1) the extraction of foul air, pure air flowing in to take its place, and (2) the propulsion of pure air into the buildings, the foul air being thus forced out. Fan-wheels or pumps worked by steam or water power, or fires to heat the air in a high extraction chimney, are the means most frequently employed on a large scale for artificial ventilation of mines and large buildings, and they need only be mentioned here. Punkahs have a more important ventilating action than is generally supposed. They not only cause the rapid removal and dilution of expired air and air tainted by emanations from the skin, but each swing acts like the stroke of a piston in a box and forces air out of the openings at one side of a room, while fresh air enters by the openings at the other side owing to the slight rarefaction produced, but this effect is largely modified by the size of the room, and the energy with which the strokes are made. The cooling effect of a punkah is due to its causing a rapid change of air in contact with the skin, thus favouring evaporation of moisture from the skin, and also the abstraction of heat so long as the air is colder than the skin. Electric fans are not as efficient ventilators as punkahs. In a closed room they merely churn up the stagnant air.

Cooling.—Thermantidotes are fan-wheels, usually driven by hand, used for propelling air into a room or house, the air being cooled by passage through a wet mat of kus-kus or other grass. They are of little use as cooling agents in damp climates, where the air is already nearly saturated; but in dry climates the air of houses may readily be cooled by them to the extent of 20° F. or even more.

The evaporation of water is a powerful means for cooling air. A quantity of water in evaporating absorbs as much heat as would raise four-and-a-half

times the quantity from freezing to boiling point. The evaporation of 1 gallon of water will reduce 26,000 cubic feet of air from 100° to 80° F. The effect of cooling and moistening air to a great extent by means of wind, or air from a thermantidote, flowing through wet mats, is prejudicial to health on account of the sudden change, and perhaps sometimes owing to the use of bad water. If such means be resorted to, care should be taken that the water employed be of good quality, and it is a wise precaution to add a little potassium permanganate to it.

Wet mats besides cooling the air and increasing its moisture, act as filters, and remove a large proportion of the suspended impurities which it may contain. A similar, though lesser, effect is sometimes obtained by placing trays of water in ventilating openings, the incoming air being caused to impinge upon the surface of the water. The cleanliness of these trays and of the water requires frequent attention. In cold climates when the air has to be warmed, it is found more effectual to heat large quantities of air to a moderate degree (by means of large radiating surfaces, such as *gilled* stoves and pipes) than to heat small quantities more intensely. The same principle should be adopted in cooling the air: large surfaces of moderate cooling power being preferable to smaller ones of greater cooling power; for instance, large moderately damp mats are generally preferable to small well-wetted thermantidotes. More equable cooling is thus effected and draughts of very cold air are avoided.

Examination of Air.

The complete chemical, microscopic, and biological examinations of air are conducted on the same principles as similar examinations of water; but

these, as well as exact measurements for artificial ventilation, must be left to skilled experts. The following easy scheme will, however, be found all that is generally needful and practicable :—

(1) Inspection of premises from outside to seek any possible cause of contamination of air entering a building, such as accumulations of decaying vegetable or animal matter, foul drains or latrines, slops thrown on the ground, etc., in the vicinity of the doors, windows, and other ventilating openings, or impurities lodged in the ventilating openings themselves.

(2) Inspection of interior of building to seek causes of contamination from within, such as dirt of floors and walls, accumulations of rubbish or dirty clothes, foul drains, sinks, bath-rooms, latrines, etc.

Local inspection is as necessary in the case of air-supply as in that of water-supply: in both cases dangerous impurities may otherwise escape detection, and in both cases the probability or the possibility of contamination must be guarded against.

(3) Examination of the sufficiency of ventilation of rooms under ordinary, or still better, under minimum, conditions; for example, bed-rooms should be examined early in the morning after they have been occupied by the full number of inmates during the night, and in their usual condition of ventilation, before such doors and windows as are closed at night, have been thrown open. For this examination the two following ready tests may be employed :—

Smell test.—The Inspector, after remaining some time in pure open air, should rapidly enter the house or room, and notice the odour if any. If the air in the room does not differ sensibly from the outside air, the ventilation may be regarded as perfect. If otherwise, three degrees of impurity may

be discriminated : (1) close, (2) close and unpleasant, (3) very close and foul.

Lime-water test.—Lime-water is made by shaking a quantity of fresh burnt lime with water in a stoppered bottle, the lime is allowed to subside and the clear water is drawn off, for use, as required ; it must be kept in a well-stoppered bottle. A clean, dry bottle, preferably wide-mouthed, of nine ounces in capacity, is filled with the air to be examined by pumping in the air with a small bellows or syringe.* Half an ounce of lime-water, carefully measured, is then poured into the bottle, which is to be stoppered or corked with a clean cork (protected with wax if it does not fit very tightly) and set aside after being well shaken. After the lapse of six hours the lime-water in the bottle should still be quite clear when shaken up. If turbid, it denotes that more than 0·07 per cent. of carbon dioxide was present in the air examined.

An eight-ounce bottle will usually be more easily obtainable, and may be used for this test with half a drachm less ($3\frac{1}{2}$ drachms instead of half an ounce) of lime-water.

(4) *Measurement of superficial space.*—The floor area or superficies of a room is, for an ordinary rectangular room, its length multiplied by its breadth. If the room is irregular in shape, it can be measured in segments, and the areas of the different segments be added together. If the walls form straight lines the floor can always be divided into triangles, whatever the shape of the room. The area of a triangle is height $\times \frac{1}{2}$ base. If the walls are curved the following data may be useful. Area of circle $= D^2 \times 0{\cdot}7854$ ($D =$ diameter). Area of ellipse $= D \times d \times 0{\cdot}7854$ ($D =$ long and $d =$ short diameter).

* Or the ready method may be suggested of stuffing a clean bit of cloth several times into the bottle and withdrawing it.

Area of segment of circle $\frac{2\,hc}{3} + \frac{h^3}{2\,c}$ (h = height, c = chord). The superficial space of a room having been measured is divided by the number of occupants in order to obtain superficial space per head.

(5) *Measurement of cubic space.*—The floor area multiplied by the height of the room gives its cubic space contents when the ceiling is flat. The following data will enable the contents of gabled or arched roofs to be calculated : contents of pyramid or cone = area of base × $\frac{1}{3}$ height ; contents of dome = area of base × $\frac{2}{3}$ height. The cubic dimensions of projections, pillars, and large pieces of furniture should be measured separately and be deducted from the contents of the room. The contents thus corrected divided by the number of occupants gives the cubic air space per head.

(6) *Inlets, outlets, and distribution of air.*—In ordinary natural ventilation the same opening will serve sometimes for ingress and sometimes for egress of air, according to variations of wind and temperature. The points to be noted are that the openings are sufficiently large, sufficiently numerous, and placed at sufficient intervals to ensure not only the entrance, but the equable distribution of a proper quantity of air, it being remembered that large rooms and those containing least obstruction, such as furniture, are more easily ventilated than small rooms crowded with furniture and require proportionately fewer openings. The distribution of the incoming air is usually tested by means of the smoke evolved from a smouldering rag held close to the apertures through which the air is entering. It may thus be observed whether the air is evenly distributed or passes in a stream from one aperture to another. Instead of the smoke-test, a smell-test may be employed, any strongly smelling substance being placed at the apertures through which air is entering,

and the distribution of the smell in different parts of the room being observed. The deflection of the flame of a candle or match held at any aperture will show whether air is flowing in or out through it, even when the current is too weak to be felt.

(7) *Arrangements for cooling, warming, or moistening the air* should be examined especially with reference to the purity and sufficiency of the air supplied. Two methods of cooling or keeping cool the air of houses are commonly practised: (1) cooling by evaporation of water, (2) shutting doors and windows to exclude radiant heat and hot air during the hottest part of the day. Cooling, dependant upon methods of construction of buildings, may also be examined under this head; details will be found in the chapter on houses.

Smoke Nuisance Prevention.

Another matter which is beginning to concern the Sanitary Officer in India is the nuisance arising from the smoke from the chimneys of the factories which are steadily increasing in number in all the large centres of population. The prosperity of a place depends to such an extent on the manufactories proceeding in it that Courts do not care to interfere much for fear of hampering the work. Still the owners of chimneys which emit huge volumes of black smoke, which may be either a nuisance or injurious to health, should be called upon to abate the nuisance, which is in many cases due to the carelessness of the fireman, though sometimes there may be structural defects in the furnace. Steamers in harbour or at river side quays are often bad offenders, and endeavours should be made to keep them under control.

CHAPTER V.

SOIL.

Geology.

For a proper comprehension of the nature of soils, some acquaintance with their geological origin is necessary, as well as with their chemical composition and physical characteristics.

Igneous rocks.—It is held that the earth was once in time a mass of molten matter. As the surface cooled it solidified and formed the rocks which are termed igneous. The varieties of texture of the igneous rocks are attributed to the effects of pressure due to contraction and to different rates of cooling. Igneous rocks compose the bulk of the earth and from them are ultimately derived all the elements known to chemistry.

Aqueous or sedimentary rocks.—Water, air and carbon dioxide, acting in conjunction or separately on igneous rocks, have in course of time removed matter from them, either in solution or in suspension, and deposited it elsewhere, often in enormous masses. Rocks of aqueous origin may be either pure or mixed with organic matter. Mud, clay, sand and their varieties have been deposited from suspension, and various kinds of limestone from solution. Other limestones and chalk are organic deposits derived from the shells of marine animal organisms.

Coal, peat and bitumen are organic deposits of vegetable origin.

Metamorphic is the name given to those rocks which have been altered *in situ* by heat, pressure and chemical changes, aided by the action of water and carbon dioxide. Metamorphic rocks may have been either igneous or aqueous in the beginning.

Soils are formed by the disintegration and weathering of the surfaces of rocks under the influence of winds, water and the oxygen of the air. Additional matter is furnished to soils by animal and vegetable life. The topmost layer of the soil is generally the richest in organic remains, and contains numerous bacteria which derive their sustenance not only from organic matter, but also directly from mineral matter. A certain class of bacterial organisms plays no small part in the disintegration of primeval rock and in preparing it for assimilation by plants. Under the influence of microbic growth in the surface soil, organic matter becomes decomposed and oxidized. Nitrogenous organic matter yielding ammonia is oxidized to nitric acid. Large quantities of nitre (potassium nitrate) are hence found in the polluted soil of old towns, the potash being supplied by wood ashes and vegetable refuse; the extensive deposits of nitre which exist in many parts of India are believed to mark the seats of ancient centres of population.

HEALTHY AND UNHEALTHY SOILS.

The soil may broadly be looked upon as consisting of three layers—

(1) The surface soil or humus, which is a mixture of mineral particles with disintegrating animal and vegetable remains. It varies in depth according to circumstances, being thickest in undisturbed forest land and non-existent in dry sandy deserts which are devoid of vegetation.

(2) The sub-soil which is chiefly composed of the decomposed products of the rock stratum below.

(3) The underlying rocky strata.

The geological and chemical characters of soil affect its healthiness in so far as they influence the conformation and material of its surface, the vegetation which it supports, the amount and nature of dust and other impurities which it yields to the air, its permeability by air and water, its capacity for retaining water on the surface or in the sub-soil, and the impurities which it yields to water.

When the surface is considerably inclined a soil is more likely to be dry than when it is level, as a large proportion of rain runs off without sinking into the ground, and the deeper strata are also likely to be inclined and to promote deep drainage. For this reason, hills are well drained and their soil is comparatively dry, although more rain falls upon them than upon adjacent plains. The soil of valleys and plains at the foot of hills is generally very moist and rich in organic matter, derived from the remains of plants washed down from the hills as well as from the local luxuriance of vegetable and animal life. Impurities emanating from the soil are apt to accumulate in the often motionless air of sheltered valleys.

Igneous and metamorphic rocks are usually healthy, provided that there is not a thick layer of disintegrated rock on the surface which holds up water. There is as a rule a good slope and good drainage, the air is dry, marshes are uncommon and the water is soft and pure.

Sandstones are healthy, they are very porous and the soil and air are dry, but the water is often impure. If clay underlies the sand, the soil may be damp.

Limestone and chalk are generally dry and healthy, but the water is hard,

Gravels are dry and healthy and the water is pure.

Sand if deep, pure and unmixed with organic matter is healthy, and the air above and the water below are pure. If clay underlies the sand or if the sand is permeated with organic matter, it is liable to be unhealthy. Sometimes sands contain too much soluble mineral matter, such as iron, magnesium and lime salts, alkalies or sodium chloride, to furnish a drinkable water.

Clays and alluvial soils are generally unhealthy. Deltas at the mouths of large rivers are composed of a mixture of sand, clay and fine detritus brought down by the rivers, mixed with organic vegetable matter. The air is damp, marshes are common, and the water often impure. Such soils require careful drainage to render them healthy. Alluvial soils are also found far inland in the valleys along which rivers flow.

Made soils, consisting of sweepings and dry rubbish of all kinds from towns, are very unhealthy but improve in course of time, especially if well drained. A deposit of rubbish, if heaped up on high and well drained, may lack sufficient moisture for its due disintegration, since the process can only go on while rain supplies the necessary water during a short period of the year. On the other hand, rubbish deposited in a tank or hollow to fill it up, may be so water-logged that disintegration is delayed from excess of water. The point to bear in mind when it is suggested that any inequalities of ground should be levelled with refuse, is whether the local conditions are favourable for the rapid disintegration of the organic matter. A sufficiency of moisture and, at the same time, free drainage for the soluble products of decomposition are necessary, and this must be attained without pollution of sources of drinking water. The natural purification of made

and polluted soils is exactly comparable to that which takes place in polluted water and in the biological treatment of sewage. The complex organic substances are used as food by micro-organisms and gradually changed to innocuous mineral salts which are slowly removed by the percolating rain water. Gases are given off during the process which add impurity to the air in the neighbourhood of a rubbish heap. Until made soil is completely purified it should not be used for building purposes.

Cultivation and vegetation.—The influence of vegetation is very important. Short herbage and trees are generally healthy, while brushwood and rank herbage are deleterious. Trees keep the surface of the ground cool by protecting it from the sun, thus diminishing exhalation from the soil; they promote dryness of the soil and coolness of air in damp places by taking up moisture from their roots and evaporating it on the great extent of surface afforded by their leaves, the amount of water so evaporated being much greater than that which would pass off from the surface of the ground shaded by the trees; they feed upon matters which pollute the soil and the air, and thus act as purifying agents. They may act injuriously by obstructing movement of air and drainage of soil and increasing moisture of air; but belts of trees may also be useful to protect from malaria by offering obstruction to the flight of mosquitoes from their breeding places. Brushwood is generally bad; it adds to the organic impurity on the surface and obstructs the passage of air, the oxidation of surface impurities and the growth of herbage. Long rank herbage may act in a similar way. Short herbage, however, is always beneficial; it keeps the surface cool, promotes evaporation, lessens exhalation and dust, feeds on impurities.

Dry cultivation, for similar reasons, improves the healthiness of a locality. Regular tillage appears

to be always beneficial. Wet cultivation, however, is not as a rule, favourable to health, but it is probably more so than allowing damp lands to remain uncultivated.

Air in Soil.

Air contained in soil is very impure as it is mixed with the gaseous products of decomposition of organic and inorganic constituents of the soil. The quantity of the ground air depends upon the looseness of the soil. It is rich in carbon dioxide, is moist, and contains organic matter. The actual composition differs in places and at different times in the same place; but as a rule, the amount of oxygen diminishes, and that of carbon dioxide increases, with the depth. The oxygen is absorbed to oxidise organic matter, and carbon dioxide is one of the results. The percentage of nitrogen remains the same as in the atmospheric air. Workmen, who have descended deep unused wells, have sometimes died from want of oxygen before they could be rescued. It is important that such impure ground air should be prevented from rising within houses by rendering their basements impermeable. It is also important that the flow of air into and out of the soil should be limited as much as possible in the neighbourhood of habitations. The movement of air into and out of the soil is caused by wind pressure; by differences in barometric pressure; by differences of temperature: when the soil is warm and the upper air is cold, air leaves the soil and conversely; by differences in the level of the sub-soil water: water rising in the soil displaces air, and a fall in the sub-soil water sucks in air. The ground air, therefore, is in continual movement owing to diurnal changes of temperature, the fall of rain, which at first displaces the superficial air and later drives it out from below by raising the level of the

ground water, barometric pressure, and winds. A house artificially warmed and not furnished with an impermeable basement, draws-up air from below from considerable distances, and from cess-pools and leaky drains, if they exist beneath or near it. Hence the unhealthiness of houses on made soils. Heavy rain forces out ground air, and, as rain does not fall within houses, the ground air tends to escape most readily through their floors, if permeable. This fact may possibly have some connection with the increased mortality which follows the rains in India. The amount of air in soil depends on its density. Hard rocks contain little or none, while porous soils may contain from 30 per cent. to 70 per cent. of air.

Water in Soil.

More or less *moisture* exists in all soils, even in the most compact rocks. Some soils, such as heavy clays; are very tenacious of moisture, while others, such as pure sands, are easily dried. Moisture does not, as a rule, fill up all the spaces between the particles of soil, but merely forms a coating upon these particles, or is absorbed by organic matter in the soil, or exists in a loose state of combination with some mineral substances. In damp soils the contained air is saturated with watery vapour. Moisture in soil is an essential factor of decomposition and promotes the growth of animal and vegetable life, including that of the numerous micro-organisms which may exist in the ground. Dampness of soil is one of the most important and common of the causes which render certain localities less healthy than others. Phthisis and rheumatism are particularly prevalent on cold, damp soils. Numerous instances are known where an increase of dampness produced by irrigation works or by obstruction to

drainage * has resulted in a great increase of sickness and mortality from malarial fevers.

Sub-soil water is the term usually applied to water which fills all the interspaces in a porous soil. It flows, more or less slowly, through the lower layers of such a soil where it rests upon impermeable rock or clay. This is the first water which is tapped on digging a hole in the ground, and furnishes the supply of shallow wells. The depth of sub-soil water from the surface of the ground varies much in different places and at different seasons; in some localities with considerable inclination it may all run off rapidly after rain, and none may be found in dry seasons. Sub-soil water influences the moisture of the ground and of the air above it as well as the amount of ground air. When it is only a few feet or less from the surface the ground above must always be damp. When sub-soil water rises it displaces a proportionate quantity of ground air, and when it falls more air enters the ground, which is left moist and in a condition to favour decomposition and the growth of microbes. It is therefore apparent that, where the level of sub-soil water can be regulated, it should be kept (1) as low as possible and (2) at a constant level. The sub-soil or ground water is always in motion towards its outfall, a river or the sea. Its rate of flow depends on the inclination of the impermeable strata which direct its course and on the porosity and density of the soil it has to traverse. If near the surface its flow may be assisted and its level consequently lowered by cutting deep trenches or laying unjointed, porous pipes in the soil, which afford the water an easier and quicker route than through the interstices of the soil. The flow may, on the other hand, be obstructed by great

* The cases of the Ganges and Jumna irrigation canals, silting up of channels in Burdwan, and on a smaller scale at Kambam (*vide* Mr. Farmer's Report) may be mentioned as examples.

engineering works such as railway embankments, and a formerly dry and healthy locality may thus become damp and unhealthy. In alluvial soils, where alternate strata of sand and clay are found irregularly mingled, an area which is damp, owing to the rain-water being held up in a cup-like depression of clay, may sometimes be completely drained and dried by digging through the impermeable strata of clay, and thus allowing the water to drain away into the sand beneath. The same arrangement of the sub-soil sometimes leads to disappointment when persons endeavour to obtain more water by deepening a well or tank, for, instead of obtaining more, they lose all that the well or tank contained if they penetrate the clay layer and get into a layer of sand which does not hold water or is not saturated. This accident is not unheard of in Madras.

Heat of the Soil.

Dark-coloured soils absorb heat more quickly than light-coloured ones, but light soils reflect both light and heat more than dark ones and cause trouble from glare. The radiation of heat from soil at night depends on its texture and the amount of vegetation, but soils in general cool more rapidly at night than they are warmed by the sun in the day. Moisture in a soil causes it to be warmed more slowly.

The surface of the ground is generally warmer than the air by day and cooler at night. Heat penetrates but slowly into a soil, so that at a depth of 30 feet or so the seasons are almost reversed, the highest temperature being found in the cool season and the lowest in the hot season.

In India it appears that the maximum soil temperature at a certain depth is reached towards the end of the rainy season, and this may have some as yet unexplained connection with the prevalence of

intestinal diseases in epidemic form at about that period of the year.

MICRO-ORGANISMS IN SOIL.

Soil contains vast numbers of bacteria varying with local conditions. Generally speaking, the more organic matter in soil the more bacteria, but the numbers diminish as the depth below the surface increases. Earth is one of the best microbic filters known, and so, when the sub-soil water level is low, surface organisms are filtered out before they reach it and the water contains few of them: but when it is high, and the intervening layer of soil is thin, porous or cracked, numerous organisms find their way directly into the water.

Soil bacteria may be roughly classified as follows:—

Saprophytic.—(1) Oxidising or nitrifying organisms—

(*a*) those which oxidise ammonia into nitrous acid,

(*b*) those which oxidise nitrous into nitric acid.

(2) Reducing or de-oxidising organisms, those which reduce nitric and nitrous acids. Class (1) is the more numerous and important, but it appears that the same organism can sometimes oxidise and sometimes reduce.

Pathogenic.—Such as the bacilli which cause tetanus, anthrax, malignant œdema, epidemic summer diarrhœa and possibly others.

Nitrification proceeds differently in different soils. It depends not only on the presence of abundance of the necessary bacteria, but also on the temperature, amount of moisture and aeration. A nitrifying soil must also be alkaline in reaction.

Peat deposits which are acid are almost sterile, which accounts for the persistence of the contained vegetable matter without decomposition for centuries.

The *humus* layer of the soil with its contained micro-organisms exerts a most important influence in the world. In it all the waste animal and vegetable organic matter of the world is changed into substances available for the food of plants; without it the surface of the earth would soon be covered with putrefying material, and life could not continue. The more organic matter contained in the humus, the more micro-organisms there are, and the greater number of these are found near the surface. The purifying power of the soil is, however, limited, and if more organic matter is put into it than the bacteria can deal with, the air above it, the water that flows beneath it, and the soil itself become loaded with imperfectly oxidised poisonous products. Instances of this are furnished by ill-managed sewage farms which are supplied with more sewage than can be dealt with, and in nature by marshes and certain parts of virgin forests.

Most of the organisms found in the soil are harmless saprophytes, but many pathogenic organisms, if accidentally introduced, can live and multiply for variable periods. Some are found with such frequency that the soil must be looked upon as their natural habitat. Two of these are exceedingly common in India, the bacilli of tetanus and malignant œdema. In street accidents, when wounds get filled with dirt, these bacilli also find an entrance, and fatal results not unfrequently follow even an insignificant wound.

THE RELATION OF SOIL TO DISEASE.

Numerous diseases have from time to time been connected with soils, but the subject is a very com-

plex one and involves consideration of the rainfall over long periods, barometric pressure, the changes in the level of the sub-soil water, not to mention contemporaneous sanitary improvements, so that very little is definitely known. Several pathogenic organisms are able to live and even multiply in the soil for a certain time, though it is not their normal habitat, and several kinds of parasites may spend one stage of their existence in the earth, but whether apart from its contained water, air, refuse added by human agency and natural organic deposits, the soil itself has any particular influence on human health, remains to be proved. As regards herbivorous animals there is plenty of evidence that pastures may become infected with both bacterial and parasitic diseases and may take a very long time to regain their purity and become fit for grazing grounds again ; but such accidents have really nothing to do with the soil.

Improvement of Unhealthy Soils.

Few individuals can select their place of residence, and existing centres of population cannot be moved to healthier sites. The sanitary question in relation to soil, therefore, usually resolves itself into the improvement of present sites.

Dampness and the presence of decaying organic matter in the soil or on its surface are the two principal causes of unhealthiness. The former may be mitigated by drainage, the latter by oxidation and vegetation. Drainage may be distinguished into that of the surface and that of the sub-soil. Surface drainage provides for the carrying off of rain water (with some surface impurities) instead of allowing it to sink into the soil. Sub-soil drainage provides, by means of deep or underground channels, for the removal of water contained in the soil or for lowering the level of sub-soil water. Sub-soil drains

are usually made by loosely jointed or perforated earthenware pipes, or even a layer of large stones in deep channels which are then covered in with earth. Large channels for sub-soil drainage are usually open. The removal of obstructions in natural drainage channels is often sufficient to cause a marked improvement in the dryness and healthiness of a place.*

Oxidation of organic matter in the soil is promoted by free access of air and by drainage which allows air to permeate the soil. The removal of brushwood and regular tillage are most important aids.

Sanitary and Engineering authorities are all agreed that irrigation without drainage has a most evil influence upon health, and that deep drainage improves the soil as well as the health of the inhabitants. The efficiency of drainage should especially be looked to in irrigated lands. In most parts of Madras the natural drainage is good, but in some parts of Northern India flat tracts of sedimentary soil occur where irrigation water has not sufficient outflow, and in such places malaria prevails to an alarming extent.

If for any reason improvement of an unhealthy, damp soil by drainage and cultivation is impracticable, a considerable degree of improvement may be attained by other measures, such as raising the level of the ground by cartage of soil from a distance, rendering the surface more or less impervious by pavement or other means, or covering an unhealthy area of land with a sheet of water.

The management of irrigation is a most important matter. If an increased volume of water is

* The ancient Romans fully recognised the importance of dryness of soil. Old and now silted-up sub-soil drains are to be found under the remains of their houses and in the country about Rome. The latter were also apparently used for collecting water in wells.

poured into a district, the channels, natural or artificial, which were previously sufficient for its drainage may prove insufficient; a general stagnation and rise of sub-soil water and greatly increased unhealthiness may result. Hence when irrigation is resorted to, drainage should receive special attention.

Wet cultivation should not be encouraged in the immediate vicinity of houses; but it is probable that damp, undrained soils are more unhealthy if left uncultivated than when subjected to wet cultivation, and it is generally impracticable to arrest the irrigation (and thus the food supply and revenue) of large tracts of land round towns and villages.

CHAPTER VI.

CLIMATE AND METEOROLOGY.

CLIMATE.

Climate is generally understood to mean local characters and changes of the air, with regard to temperature, moisture, pressure, wind, cloud, rain, purity, electric state, as well as the local amount and intensity of the sun's heat and light. In considering the effect upon health of residence in any particular place, all other local conditions have also to be taken into account. That climatic conditions have a very pronounced effect upon health is proved by the geographical distribution of diseases, and still more so by their seasonal prevalence.

Climate undoubtedly has a great influence in determining the characteristics of the races of mankind, the most obvious effect being variations in the pigmentation of the skin. There may be even more radical differences in the functions of internal organs which have not yet been recognized. Human beings are very adaptable and it now appears to be fairly certain that, if adverse influences be rendered inoperative, which were formerly attributed solely to climatic conditions, a representative of a cold climate may flourish in a hot one, and a native of the tropics may retain his health and vigour in a cold place. In each case, the requirements are suitable food, pure water, sanitary surroundings, proper clothing and temperate habits.

It is as yet an undecided point whether there is such a thing as acclimatisation, that is to say, a

structural and functional change in the organism to meet new conditions, which takes a certain time to accomplish itself in new comers.

It seems more probable that there is an increase in function of some organs and a diminution in the work done by others which enables the organism to accommodate itself speedily to its needs. Whether these changes would become perpetuated in the race in the course of generations cannot be told : no statistics of value exist which have a bearing on the question, for, even when the race remains pure, there are so many outside influences to be allowed for that definite conclusions cannot be drawn.

The main reason why Europeans break down in health in the tropics is because they do not adapt themselves sufficiently to local conditions in the matter of food, drink and habit, particularly the last. The average European in the tropics does a longer and more arduous day's work under adverse conditions than the average European in his own country. Not content with that, he further exhausts himself with his play and recreations, again expending more energy than he would in the land of his birth. Briefly put, he has too little leisure.

Temperature.—Temperature affords the most usual basis for the classification, and the simplest division is into hot, temperate and cold. But in places with the same mean temperature the extreme fluctuations may be very great or very small. In islands and on the sea coast the difference between the hottest and coldest seasons is least marked, and such a climate is termed equable. On the other hand, the climate of regions far inland is extreme, being very cold in winter and very hot in summer.*

* As an example it may be mentioned that the difference between the mean temperature of the hottest and of the coldest month in Madras is only 12° F., while in Peshawar the difference is 39° F.

Besides annual fluctuations, both daily and irregular fluctuations also occur; in constant climates such fluctuations are small, while in inconstant or variable climates they are great, there being much difference between the day and night temperatures, or frequent, sudden, unseasonable changes. Inland and temperate climates are generally the most variable, hot island and coast climates the most constant.

Temperature has an important influence upon health. Variable temperate climates and climates subject to extreme differences between hot and cold seasons are those which produce the most vigorous races of mankind: this is probably due to natural selection, for weakly people are constantly killed by great changes of temperature. Constant and equable climates, on the other hand, especially when hot, moist, and well supplied with food, tend to produce a weakly and languid race of men. The prevalence of particular diseases is much affected by temperature; in cold and changeable climates, diseases of the lungs are very prevalent and fatal, and rheumatism is frequent, while in hot climates, diseases of the bowels and liver and malarial fevers are very common. Some diseases, such as malaria and cholera, are arrested by cold; and high temperature, combined with dryness, arrests plague and is unfavourable to other diseases. Exposure to the direct heat of the sun in hot climates sometimes produces an intense form of fever (sun fever), which is speedily fatal or else ends in recovery within a few days. Heat apoplexy is more frequently caused by very high temperature in the shade than by exposure to the sun; it is very rare except in persons who are in bad health or of intemperate habits.

Moisture.—The quantity of watery vapour which air is capable of containing increases rapidly with rise of temperature. For instance, at freezing

point it can only contain 2 grains of moisture per cubic foot, while at 70° F. it contains 8 grains. Therefore air which is saturated with watery vapour, or exceedingly damp at a low temperature, becomes relatively very dry when its temperature is much raised, although the absolute quantity of moisture contained in it remains the same. The absolute quantity of moisture contained in air is, therefore, much less important than the quantity in relation to temperature. The latter is usually expressed as a percentage of the quantity required for saturation at the given temperature. Thus air at a temperature of 70° F., containing 4 grains of aqueous vapour per cubic foot, would be said to have a humidity of 50 per cent.

From this it will be understood how air which is relatively dry at a high temperature becomes moistened and even saturated as its temperature is lowered. If the temperature be lowered below the point of saturation (dew-point), the excess of moisture is deposited in the form of water, as dew, rain, cloud, mist. Hence the dampness of cool evening air and the deposit of dew on cold surfaces. On the other hand, when the temperature of saturated air is raised, it becomes relatively dry and capable of taking up more moisture, and the hotter it becomes, the more does it encourage evaporation.

Temperature, therefore, has great influence upon the moisture of the air, so also have large bodies of water and the nature of the surface. Mountains, as the Western Ghâts during the south-west monsoon, deprive winds passing over them of much moisture and cool them, but render the climate more variable at the other side by removing vapour from the air. The presence of aqueous vapour in the air, even when not deposited in the form of cloud, obstructs the passage of heat. Thus in places where the air is damp the heat of the sun is slightly moderated,

but rapid radiation of heat from the ground is considerably prevented, the climate being thus rendered equable. Dryness of the air, on the contrary, favours great solar heat in the day-time and rapid radiation from the ground, causing comparatively hot days and cold nights. Moisture further tends to produce equability of climate by the cooling effect of evaporation when the air is heated, and by the liberation of latent heat when vapour is condensed as the air cools.

Moist climates are, other things being equal, undoubtedly less healthy than dry ones. Many reasons may be assigned for this. Moisture of air and of soil generally go together, and the evil effects of moisture of soil have been already noticed. Micro-organisms multiply more readily and are more abundant in moist than in dry air. Moisture is an essential factor in the production of putrefaction. Evaporation from the skin and lungs and capacity for exertion are lessened by moisture of air.

The mean annual moisture of air on the coasts of India is about 70, and in the Deccan and dry parts of Northern India about 55 per cent. of saturation quantity. On the coast the range is small, about 20; in the interior it varies from 30 to 50.

Pressure.—The pressure of air at the sea-level is equal to that of about 760 millimeters (30 inches) of mercury, or about 34 feet of water, or a weight of 15 pounds on every square inch of surface. As we ascend above the level of the sea this pressure diminishes; thus at Bangalore it is equal to that of 27·7 inches of mercury and at Ootacamund of only 23·5 inches. The effect of diminished pressure is to cause expansion of the air and to encourage evaporation. The small changes of pressure observed in any one place can have no perceptible effect upon health. The physiological effect of considerably

diminished pressure is to increase the rapidity of the respiration and the pulse; but no injurious effect is produced upon previously healthy persons by a diminution of pressure such as occurs up an altitude of 9,000 feet above the sea.

In considering the effect of high altitudes above the sea level upon climate and upon health, other factors, besides diminished atmospheric pressure, have to be taken into account. Thus the temperature becomes lower as we ascend, radiation of heat being much increased by the lessened thickness of air and greatly lessened amount of aqueous vapour through which it has to pass. The air of high regions is often very dry owing to good drainage of the ground, rapid evaporation and free movement of air. Increased purity of air is one of the factors of healthiness in such places; impurities of all kinds, including micro-organisms, rapidly diminish as we ascend. Well-drained soil, pure air, pure water, lower temperature, and often increased exercise, are, more probably than any effect of diminished air pressure, the real causes of healthiness in hill climates.

Wind.—Stagnation of air greatly favours the accumulation of all kinds of impurities in it and lessens the rapidity of oxidation. Constant movement of air is therefore beneficial. Such movement, and indeed wind generally, is caused by alterations of temperature. The good effect of wind in dispersing and destroying organic impurities, is, however, far more predominant than any injurious effect. The temperature and moisture of the wind, depending upon the surface over which it has blown, has often a very marked influence upon the climate of a locality. Though moderate movement of the air is beneficial, violent movement is not so. High winds, especially if cold, are likely, by chilling the skin, to excite congestion of internal organs, and

they may increase the impurity of air by raising dust.

Cloud.—When moisture-laden air becomes cooled to below the dew-point from any cause, such as meeting a current of colder air, cloud or mist results, or large drops of rain may be formed. Clouds thus denote a supersaturated condition of the air in which they exist. The air near the ground may, however, be dry, while clouds exist higher up. The effect of clouds is to promote coolness of climate by arresting heat from the sun and equability by arresting radiation of heat from the earth. They may exert an unfavourable influence by interfering with light which is required for the health of plants and animals.

Rain.—Rain is beneficial by washing impurities from the air and supplying necessary water, besides cooling the air. Heavy rain washes impurities from the surface of the ground into the soil and into water-courses, and is unfavourable to the production of malaria during its continuance. Light rain encourages decomposition of substances upon and in the soil, the growth of microbes, and the production of malaria. Therefore in places with a heavy rainfall we find fever most prevalent some time after rain, and in places with a light rain-fall it prevails during the rains. The effect of rain upon the moisture of air and soil is obvious. There is often a remarkable contrast between the amounts of rain which fall in one place at different seasons of the year, and the total amount at different places also shows extreme contrasts.

Purity of air has been already discussed in the chapter on Air. Little is known regarding the influence of electric conditions of the air upon health.

The Sun is the source, directly or remotely, of all energy upon the earth. This energy is transmitted

in the first place as radiant heat and light. Green plants especially, and most animals to a lesser degree, require heat and light for their development. Green plants under the influence of light decompose the carbon dioxide gas which is evolved by animals and by the decomposition of organic substances. The direct heat of the sun is useful in promoting dryness of the surface and probably in destroying micro-organisms, as well as in causing currents of air. Moderate exposure to it is beneficial to men in cool climates, and is not necessarily detrimental to their health in hot climates.*

Light, however, is much more necessary and conducive to health than heat, though its mode of action on animals is not well understood. Excessive light, as reflection from a light-coloured soil or from snow, is very prejudicial to the eyes.

Meteorology.

Is the science of observation of climatic phenomena. In the reports on the meteorology of India, observations of the following points are recorded, being collected from numerous observations in every part of India :—

(1) Solar radiation and duration of bright sunshine.

(2) Nocturnal radiation and temperature of the ground.

(3) Temperature of the air.

(4) Atmospheric pressure.

(5) Wind direction and movement.

(6) Hygrometry.

(7) Cloud proportion.

(8) Rain-fall.

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* In hot climates indeed the most vigourous and hardy people have a good deal of such exposure. The Arabs and Persians speak with contempt of "shade-nurtured" weaklings.

Temperature of solar radiation is a measure of the direct heat of the sun. The solar radiation thermometer is a self-registering mercurial thermometer, having the bulb and half an inch of the stem coated with lamp-black, and it is enclosed in a large glass tube from which the air is exhausted. The bulb is blackened to render it more absorbent of heat, and the outer tube serves to protect it from currents of air. This thermometer is easily affected by surrounding objects. It is corrected by comparison with an arbitrary standard instrument.

The duration of bright sunshine is measured in a few places by the sunshine recorder, which consists of a spherical glass lens, having a curved brass plate fixed beneath it at such a distance that the focal point in which the sun's rays converge travels across the surface of the plate between sunrise and sunset. A slip of card, with printed divisions corresponding to hours, is inserted in grooves on the plate, so that when the sun shines brightly the line is burnt on it; measurement of this line gives the time of bright sunshine.

Nocturnal radiation from the ground is measured by a minimum self-registering spirit thermometer laid on a thick pad of common country blanket which affords a more uniform radiating surface than grass or bare ground. The temperature of the ground at various depths is observed at only a few stations.

Temperature of the air is observed in most places only twice daily, at 10 A.M. and 4 P.M., by means of an ordinary mercurial thermometer (the dry bulb of the *dry and wet bulbs*). The readings, together with those of the maximum and minimum thermometers, afford the data for the deduction of the mean temperature. The highest and lowest

temperatures of the air in the shade are recorded by means of a mercurial self-registering maximum and a spirit self-registering minimum thermometer, the indices of which must be set daily after reading. These thermometers are kept in a cage fixed to one of the supports of a thatched shed, open all round, the bulbs of the thermometers being 4 to 4½ feet above the ground.

The atmospheric pressure is measured by a mercurial barometer.* The barometers are kept in masonry buildings to protect them as much as possible from changes of temperature. The mean pressure is determined from two (sometimes three or four) daily readings, in some cases corrected by results of hourly observations in former years. The corrections of the readings for temperature, etc., are made in the central offices.

Wind.—The direction is observed at 10 A.M. and 4 P.M. The anemometer reading shows the rate of wind in miles per hour.

Hygrometry.—The moisture of the air is calculated from the difference between the readings of the dry and wet bulb thermometers at 10 A.M. and 4 P.M. and by the minimum dry and wet bulb readings. These instruments must be freely exposed to the wind in thermometer shed. Not only humidity but altitude and temperature of air influence the temperature of evaporation (wet bulb).

Cloud is estimated in the usual way by looking all round, overcast sky being noted as 10 and cloudless sky as 0. Observations are made at 10 A.M. and 4 P.M.

Rain is generally measured at 6 P.M.

The Method of using Meteorological Instruments

Must be learned practically at a meteorological observatory or a physical laboratory. Full descriptions of these instruments would therefore be superfluous in this place. The principle only of the most important instruments will be briefly explained.

The barometer is a balance for weighing the pressure of the air. Mercury is used because it is the heaviest known liquid. When a long tube, closed at one end, is filled with mercury, and its open end is inverted in a cup or cistern full of mercury, the pressure of the air on the surface of the mercury in the cup keeps the mercury in the tube pressed up to a height of about 30 inches, supposing the experiment to be performed at the sea-level. As we ascend above the sea-level, the weight of the air above us, and consequently the height of mercury in the barometer tube, becomes less and less. Therefore the barometer may be used for ascertaining the height of any place above the level of the sea. The following table shows the number of feet ascended for each inch fall of the mercury from 30 inches to 22 inches:—

Inches of mercury.	29	28	27	26	25	24	23	22
Height in feet for every inch.	886	918	951	986	1,025	1,068	1,113	1,161
Total height ...	886	1,804	2,755	3,741	4,766	5,834	6,947	8,108

The fluctuations of the barometer in one place indicate changes in the density of the atmosphere above. These are mainly due to variations of temperature and moisture and air currents, which

may occur in the upper regions of the air as well as near the surface of the ground.

The aneroid barometer is a very portable instrument. Its indications depend upon the contraction or expansion, under the influence of atmosphere pressure, of an elastic metal box from which the air has been partly exhausted. It is regulated by comparison with a mercurial barometer.

Thermometers are instruments for measuring the intensity of heat. The expansion of mercury is commonly employed for the purpose, mercury being selected because it is affected by small quantities of heat and expands equally at different temperatures.

The maximum thermometer is provided with an index which is pushed up by the column of mercury and remains at the highest point reached.

The minimum thermometer is made with alcohol instead of mercury, and contains an index which is drawn down by the alcohol to the lowest point reached and is not pressed up by the ascending alcohol.

The wet bulb thermometer has its bulb constantly kept wet by an envelope of cotton cloth in communication with a cup containing water. This thermometer therefore gives the temperature produced by evaporation, and, as water in evaporating absorbs heat, it must always indicate a lower temperature than the dry bulb thermometer except when the air is saturated with moisture and no evaporation can take place. Other conditions being unchanged, the drier the air the greater will be the difference between the indications of the wet and dry bulb thermometers. The rapidity of evaporation is increased not only by dryness of air, but also by increase of temperature and diminution of pressure, conditions which have to be taken into account in calculating the moisture of the air from dry and wet bulb thermometer readings.

The rain gauge is an instrument for measuring the rainfall. It consists of a carefully-made funnel of exact calculated size at the rim and a measuring vessel in which the water is collected.* A commonly used size for the funnel is 4·697 inches in diameter; $\frac{1}{10}$ inch of rain falling into this gives 1 fluid ounce of water.

The anemometer is a self-recording instrument which shows the amount of wind. It consists essentially of a horizontal wheel with four spokes, each of which bears at its extremity a half-spherical cup. The pressure of the wind on the concave surface of such a cup is one-fourth more than on the convex surface.

* The square area of the circular aperture may be easily calculated ($d^2 \times 0{\cdot}7854$), and conversely we may calculate the size of circle equivalent to any given square surface.

CHAPTER VII.

HOUSES AND BUILDINGS.

Good health largely depends upon the healthiness of the houses in which people sleep and also spend a portion of the day. The two primary causes of unhealthiness in houses are *damp* and *dirt*. Dirt is here taken in its most comprehensive sense as including foulness of soil, dust, rags, and refuse in and about the house, and foulness of air from contamination by such dust and refuse, deficient ventilation, latrine, sewer, or ground emanations and other causes.

Damp and dirt, especially when they co-exist, greatly encourage the growth of microbes; it is a matter of common observation that circumstances which favour such growth are unfavourable to health, even if the microbes present be not themselves specific causes of disease. Damp, dirt, and overcrowding not only encourage the spread of epidemic and all communicable diseases, but foster other diseases and produce a general low state of health by interfering with the physiological functions of the body, particularly those of the lungs and skin. The demolition and reconstruction of unhealthy houses has been attended with excellent results in many towns. For instance in Glasgow "it was proved by special investigation that the people whose wretched houses were demolished by the Improvement Trust distributed themselves over the city. It is often said that the habits of these people are such that, go where they please, they will not be the better for the change. It is evident, however, that

they found physical conditions so much more conducive to health that, whether or not their habits have been improved, undoubtedly their health has been, in their new residences."* Demolition or improvement of insanitary dwellings in one direction is of little use however, if the erection of similar dwellings in other directions is not prohibited.

In towns the effective control of building operations is comparatively easy, but in villages it is more difficult; the diffusion of hygienic education will do much to assist such control. No town can be very healthy or well-ordered where sanitary building regulations do not exist or are not enforced.

The advantages derived from a good water-supply and efficient drainage are annulled by a bad arrangement of huts and houses. Ill-ventilated and crowded localities always have a high death-rate, and collections of dwellings erected on no previously drawn out plan generally have narrow and crooked lanes which present great difficulties to conservancy officials.

Landowners are generally desirous of getting as much value out of their property as possible, and will encourage the erection of dwellings of any type as long as it adds to their ground rental.

In order that the conservancy work of an Indian town may be properly accomplished, a close watch must be kept by the sanitary officials to see that their gang-ways are not obstructed.

Plans for the demolition and reconstruction of every insanitary and overcrowded area in a town should be ready in every Municipal office, so that when the opportunity for improvement arises, it may be seized before it has passed.

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* *Vital Statistics of Glasgow*, by J. B. Russel, M.D., LL.D.

Streets should be as uniform as possible, having due regard for structural variations and architectural fancies, for uniformity of building facilitates connections with drains and water-pipes. Mean buildings in a good street should be discouraged as far as possible. More open spaces in the form of squares and public gardens are required in Indian towns generally; not only for purposes of ventilation, but also to afford room for children to play. In many places the sole available sources of recreation of the children of the poorest classes are the street dust-bins and open drains.

An open space occupied by a large tank serves the purpose of ventilation but not that of recreation, and tanks often have the disadvantage of rendering their immediate neighbourhood damp and unhealthy. The time when tanks were necessary to supply drinking-water, bathing and washing facilities to the populace is passing away with the introduction of piped water supplies, and tanks tend to be neglected and become receptacles for refuse.

In securing healthy dwellings, purity of air is the object to be aimed at, and the means of attaining it may be summed up as follows:—

(1) A dry site with a house so constructed that its floor and walls are always dry and that its roof does not leak.

(2) A sufficient supply of pure water whereby the house may be kept clean.

(3) A proper system of removal for waste water and excreta.

(4) Efficient ventilation of all parts of the house and admission of plenty of light.

Preparation of Site.—High, dry, sloping ground is the best, whether the soil be permeable or not. As a rule, however, the site of a house is not a matter of selection, and it has to be built

where ground is available. If the soil be permeable, and particularly if it be damp, deep sub-soil drainage should be resorted to. If this cannot be done, the level may be raised by bringing clean earth or sand from another place. For small houses or huts a platform of loose stones may be made. Brushwood should be removed, hollows filled up, and surface drainage provided for.

The **Ground Floor** should be raised above the level of the ground outside so as to facilitate cleaning and promote dryness. It should be water and air tight in order to exclude damp and exhalations from the soil. For mud huts a thick flooring of well-puddled mud may be used. A coating of hydraulic cement, should, if possible, be laid over this. If this is not done, special care should be taken to build on a high, dry platform and to make the floor as high as possible above the ground. In very damp places, wooden or bamboo huts* may, with advantage, be raised above the ground on piles, and large houses may be built on platforms raised on open brick or stone arches. The basement floor of large houses is best made of a thick layer of concrete. The level of the flooring in all houses and huts in India should be raised to form a *plinth* not less than 2 feet high. This serves to keep the house both drier and cleaner, and it is undoubtedly more healthy to be raised even that much above the general level of the ground. Expense incurred in bringing earth from a distance is the objection most frequently raised against the fulfilment of this regulation, and care must be taken to prevent pits being dug in the immediate neighbourhood to obtain the necessary earth, as these frequently become stagnant pools filled with mosquito larvæ and otherwise objectionable. The practice of excavating earth

* As in some parts of Burma.

from the actual site of a hut to provide mud for its walls must be condemned, for the completed structure will have its floor from one to two feet below ground level.

Walls are intended to exclude damp, great heat, great cold; the most suitable materials and method of construction will therefore largely depend upon climate, but the materials employed by the great majority of the population must be the least expensive and most readily obtainable. Mud is employed everywhere, and sun-dried or even burnt bricks or stone, bedded in mud or mortar, wood, and bamboo matting, plain, tarred, or plastered with mud, are used in various parts of the country. Impermeable materials are generally the best for walls because they effectually exclude damp from rain beating on them, do not soak it up from the ground, and do not absorb organic matter from air. To prevent damp rising from the ground in brick and mud walls, a *damp-proof course* should be inserted in the lower part of the walls. This is best made continuous with the damp-proof layer of the floor, and may be made of tarred brick, which would be a very cheap material for mud huts, or of hydraulic cement, impermeable stone set in cement, asphalte or vitrified tiles. A damp-proof course may be inserted in an existing wall without pulling it down.* Not only does a damp-proof course in the walls of a house render it drier and more healthy, but in the better class of house it is actually cheaper in the long run. Nothing is commoner than to see plaster flaking off walls and pillars, and badly burnt bricks disintegrating, under the influence of the moisture which is continually soaking up from below. Double walls are effective in excluding

* A damp-proof course would also afford some protection against white-ants.

damp, heat, and cold; the space between should be ventilated. For temporary or moveable huts, bamboo matting is an excellent material; it is very light and can be rendered air-tight or water-tight by plastering with mud, or tarring, or covering with tarred cloth. When plain, it provides excellent ventilation; nothing could be better for temporary or even permanent hospitals in hot climates; when dirty it can be washed, or burnt and replaced.* For the outside of walls, plaster or lime wash is often used, but this can have no particular hygienic effect. Hydraulic cement is good for excluding damp.

For the interior a coating of some smooth impermeable material, which is non-absorbent and can be easily cleaned, is best.† This cannot commonly be provided however. Mud walls may be left plain or be white-washed from time to time with fresh-burnt lime. The common fashion of plastering walls and floors with cow-dung and water is decidedly to be condemned; it renders them damp, affords material for the propagation of micro-organisms and pollutes air.

Upper Floors.—The value of land in towns and the convenience of being near their places of business is leading owners more and more to add upper floors to their houses. Generally speaking, there is no objection, but it may happen that the street is so narrow that free perflation is obstructed by raising storeys all along it. Often too it happens that a second storey is added to a house which originally was never designed to bear one, the result being that light and air are almost completely

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* It has been in use for some years in the contagious wards of the Madras General Hospital.

† Care must be taken not to use paint containing arsenic or other poisonous material. Arsenic occurs most commonly in green colours, and

shut off from the ground floor. Latrines and urinals in the second storey are not to be encouraged: they are almost unavoidably a nuisance.

Roofs are designed to keep out rain and heat, while it is an advantage for them to permit some passage of air. They are constructed in various ways, depending to a great extent upon the climate and the materials available. When the materials do not permit the passage of air, ridge ventilation ought to be provided. Roofs made of thatch or other materials, which harbour insects and other vermin, may usefully be lined inside with tarred paper or matting.

For protecting against the heat of the sun, the principal devices are thickness and non-conductibility of material, height,* light colour externally, and double roofs.

Rain water which falls on a roof should be carried off by channel pipes fixed to the eaves, or else be received on a paved surface and be carried away by surface drains, so that it may not soak into the ground close to the walls.

Verandahs are of great use in hot and wet countries to protect the side walls of a house from solar heat and from beating rain. They are also very useful as well-ventilated day-rooms and as sleeping places in sultry weather when the air is stagnant and ventilation fails within doors.

Outhouses and stables require as much attention as regular houses in order to preserve the health of persons residing in or near them and that of animals in them. Dryness, ventilation, good

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* In accordance with a well-known physical law, the heat radiated from a roof is inversely as the square of its distance. Therefore the direct heat reaching a person from a roof 5 feet above him is four times as much as would reach him if the roof were 10 feet above him.

water-supply, drainage to remove urine and dirty water, and regular cleansing must all be looked to.

House Interiors.—Much remains to be done in India in the way of designing commodious and sanitary buildings for the occupation of both natives and Europeans. Where sufficient space is available a good native house can easily be erected, but the worst types are found in towns, where the area to be built on is confined and often irregular. Desire for privacy leads to defective ventilation and lighting, and avarice on the part of the landlord generally leads to overcrowding. In Madras the Municipal Acts give power to the local authority to prevent insanitary buildings being erected ; and improvements in the future in the way of the gradual disappearance of unventilated and unlighted rooms, cook-rooms without smoke vents, porous brick floors, walls without damp-proof courses, latrines in inaccessible spots often adjoining a well either in the same or the next house, and the like, may be expected. Cattle and poultry should not be permitted to wander at will about the house. The latter especially often obtain their living only by careful search through dust-bins, heaps of garbage and even excreta in the streets. In the house the centre of attraction for them is naturally the cook-room, where during raids upon the victuals they may manage to shake off their feet the dirt picked up in the street.

Railway companies and other public bodies often run up exceedingly insanitary buildings for their employees and coolies: any attempt of this nature must be resisted. The smaller the house, the more necessary does free perflation become ; and back to back dwellings, which can get no through draught, are everywhere to be avoided.

The cleanliness of house interiors and yards is an important matter. The Hindu is not usually a

sinner in this respect, though he has a habit of collecting refuse in out-of-the-way corners where it does not readily catch the eye. The custom that obtains amongst certain communities of covering the floor with matting is a most insanitary one when the mats are only removed at long intervals of years. By far the better plan is to have a cemented, tiled or mosaic floor as circumstances allow. This can be kept absolutely clean by swabbing with a wet cloth or mop. Brooms, together with the people who usually wield them, are better excluded from the insides of houses; they merely raise and displace dust without removing much of it.

Streets are the channels by which air reaches the houses. If the streets are dirty and narrow, the ventilation of the adjoining houses is insufficient. Every effort should be made to keep streets as clean and as free from garbage as possible, and this is more easily performed in thickly populated parts if the surface is well paved. No house or building should be more than half the width of the street it faces in height, otherwise ventilation and light are interfered with, and this should always be borne in mind in planning extensions and remodelling condemned areas. It must not be forgotten when applications are received for adding storeys to houses already in existence.

In populous parts of a town, not more than two-thirds of the whole area should be covered by buildings, including verandahs and out-houses, the remaining third, or still better one half, should be left for open spaces and streets.

Any encroachment on streets by so-called "temporary" tatty-verandahs, sunshades, or other form of impediment to the free passage of air, should not be countenanced by the sanitary officials.

The same rule that applies to the height of the houses bordering a street should be adopted with

regard to the height of the parts of a house opening on to its central passage or courtyard, that is to say, the height of the building at each side of the courtyard should not be more than half the width of the yard.

Similarly when there is a tendency to build long and narrow dwellings, the length or depth from the roadway should be limited to 45 feet, unless lateral windows are possible, which open into a free space not merely a scavenger's gangway.

Public Buildings especially schools, hospitals and barracks, where persons are congregated in considerable numbers, require great attention to hygienic arrangements. Ample ventilation and water-supply is particularly necessary for hospitals. Hospitals and barracks are however generally well looked after, but schools are often completely neglected. This is a matter which requires special attention, not only with reference to the present health of children and the prevention of epidemics, but because "the child is father of the man"; bad physical development tells throughout life and insanitary habits acquired in childhood are with difficulty rectified. The hygienic condition of schools therefore in every respect deserves the greatest care. Instruction in the elements of hygiene should form part of the curriculum in all but infants' schools, and children should have an object lesson always before them in the shape of school buildings arranged on sanitary principles. The cubic space allotted in school rooms should be from 400–600 cubic feet per head according to the age of the children. Spending long hours in an overcrowded room has a distinctly bad effect in course of time on both physical and mental development. Somnolence and inattention in school is frequently due to overcrowding and lack of proper ventilation. In order that a child may benefit to the utmost by

instruction, his surroundings must be healthy and the air pure. Bodily discomfort must have an adverse influence on the receptivity of a child's mind, for at the best of times children have difficulty in fixing their attention. While plenty of light is necessary to avoid strain of the eyes in reading, a glare must be avoided. To lessen shadows in writing it is best for the light to come from the left side. The height of the desks should be proportionate to the size of the scholars, so that they can place both forearms comfortably upon them without raising or depressing the shoulders. The height of the benches from the ground should be such that the feet do not dangle in mid-air, but can be rested without elevating the knees. All seats should have proper backs, not merely a rail at the level of the shoulders. Enough pure drinking water must be supplied, and a latrine removed a little from the main building with seats 10 per cent. of the total number of scholars.

Building Plans.—Plans of all new buildings as well as repairs, additions and alterations of old ones should be carefully scrutinized by the Sanitary department before permission is granted to begin the proposed work, bearing in mind ventilation, light, drainage and water-supply. Besides the office scrutiny of the plan, an inspection of the site must be made to be sure that existing sanitary arrangements are not likely to be interfered with, *e.g.*, that a latrine is not going to be built against a wall, behind which the neighbour has his well.

House-to-house Inspection.—It is the duty of every Sanitary officer to make sure that his district is thoroughly inspected at regular intervals by his staff of Inspectors for the discovery and abatement of nuisances. Each Inspector should keep a book containing details of every house in his area, in which the defects noticed can be entered, and the

action taken in each instance and its result. Some of the more important items to be noted are given below :—

Street and house number............
Name of owner............
Name of occupier............
How let—weekly............yearly............
Number of families............
Number of inmates—adults.........children under 10......
Number of lodgers—adults.........children under 10......
Number of rooms............
Number of persons to the rooms............
Number of windows . ...
Water-supply............
Position of latrine............
Condition of latrine............
Conservancy arrangements............
Position and condition of house drains ....
Connection with street drains ....
Condition of stair-case and passages............
Position and condition of cow-house and stalls............
General remarks—
Overcrowding.
Cleanliness.
Ventilation.
Water-supply.
Drainage.
Condition of building.
Health of inmates.........General sanitary condition.

Suggestions for improvements should follow and entries of the action taken with the results attained.

Markets, Slaughter-houses and Cattle-yards.—The essential sanitary points about a *market* are that it should be smoothly paved throughout and well drained to facilitate cleansing, that there should be a plentiful supply of water to wash down the stalls, and that meat and fish stalls should have no wood work about them, with the exception of a chopping block. If funds permit, a roof is desirable not only to keep out sun and rain but to exclude kites and crows. If the market be of any

size a latrine is necessary. It should be roofed in and well ventilated, and situated as far as possible from food stalls. None but stall-holders should be permitted to use it.

A slaughter-house should have a pen outside for collecting the animals prior to slaughter. Here also they can be conveniently inspected before admission to the main building. The slaughter-house must be properly paved and drained throughout, and supplied with plenty of water for cleansing purposes. Whenever possible it should be connected with a sewer—special arrangements may be made for the collection of the blood, which is valuable for making albumin, and also for manure. A room where carcases can be hung for a while before sale, known in Madras as an "airing room," is a necessary adjunct. No latrine should be allowed in the building. A roof is necessary to keep out kites and crows which otherwise assemble in great numbers and cause much nuisance, and dogs must also be carefully excluded. Adjoining the slaughtering enclosure, but outside the wall, a paved area with stalls is generally required as an offal bazaar.

Cattle-yards are generally found in, or in close connection with, dwelling houses, to the detriment of the health both of the cattle and of the human beings. If this cannot be avoided, every care should be taken to keep the sheds as healthy as possible by proper impervious stone flooring and good ventilation. They must also be connected with a drain so that they can be thoroughly washed down. The storage of dung, the manufacture of bratties, uplis, or cow-dung cakes on the premises, and the practice of sticking them on to the walls of the cow-house to dry, are to be condemned. Cow-dung heaps, if kept dry, are not particularly offensive, but if allowed to become saturated with rainwater, they are liable to be a

great nuisance. Numerous flies breed in moist cow-dung, and flies, as will be pointed out later on, are dangerous insects to encourage in and around dwellings. Since the owners of only a few cattle are generally unable to afford to keep their beasts on their premises in sheds so constructed that sanitary requirements are not violated, it is a far better arrangement in towns to build public cattle-yards which can be properly supervised, and to lease out stalls to small owners. In a large cattle shed of this kind, there should be two rows of stalls so arranged that the animals' heads face towards the outer wall with a feeding passage about 4 feet wide intervening between the wall and their heads. At the rear of each row of stalls there should be a shallow channel for receiving urine, manure and washings, with a passage way between. The whole shed must be as open to the air as possible, and well supplied with water for flushing purposes.

Bathing Places.—To discourage the custom of bathing in foul tanks where the bather washes not only his body and feet but also his clothes, and finally rinses out his mouth and spits a few times into the water before leaving it, public bathing places are extremely desirable, and are highly appreciated. A cemented enclosure, partitioned or not as required, with a plentiful supply of clean water laid on by pipes is all that is needed. Such places confer great benefits, particularly on the poorer classes and lower castes.

Dhoby Khanas.—As the washing of clothes in India is nearly always performed by a poor class of persons who have not sufficient capital to enable them to provide suitable and sanitary premises and equipment for carrying on their trade, it is incumbent on Municipal Councils, in the interests of the public, to build and equip places where dhobies can wash under supervision. A really satisfactory

dhoby khana which meets all sanitary requirements and at the same time pleases the dhobies and the ironmen has yet to be designed. The main points to which attention should be directed are the following :—

(1) A well-ventilated and dry room for storing soiled clothes safely, which can be thoroughly cleaned and disinfected.

(2) A plentiful supply of pure water.

(3) A cistern for soaking clothes.

(4) A caldron for steaming clothes.

(5) Another cistern for washing clothes, supplied with running water.

(6) A stone and an impervious platform.

(7) Efficient drains to carry off all waste and dirty water.

(8) A drying ground.

(9) An ironing room.

(10) A dry and well-ventilated room for storing clean clothes.

CHAPTER VIII.

PERSONAL HYGIENE.

So many matters related to health are in the power of individuals themselves and of heads of families, that this division of the subject is of wider practical importance than any other. Some of these matters have been already treated of; but any approach to a full discussion of all is here impossible. Other chapters must be referred to for much that is individually applicable: in this place only a few of the more salient points connected with personal hygiene can be alluded to.

HABIT.

The persistence of acquired habits is a remarkable and controlling character of all organisms. Habits, however caused, are most easily originated in early life, become confirmed by practice (though the influence of the original cause may have been withdrawn), and are potent for good or evil upon individuals, communities, and posterity. The acquirement of good habits is, therefore, of supreme importance to all individuals as affecting the health and happiness of themselves, their neighbours, and their children.

It is especially with regard to the physical and mental training of children that the influence of habit can be most productive of good and most avertive of evil; the firm implanting of healthy habits and the eradication of unhealthy ones is the highest duty of parents and teachers. For the inculcation of hygienic habits some knowledge of hygiene is needful, but the most fruitful method of

teaching them is by example in their practice. Hence parents and teachers should endeavour themselves to teach by practice, and should remember that the influence of a well-disciplined school or household, and well-trained companions upon children has a most potent and abiding good effect.

It is difficult to break acquired habits, but the oftener they are broken, the more easy is it to destroy them; in the eradication of unhealthy habits as in the acquirement of healthy ones, the difficulty is half surmounted when the first effort has been made. As some guide towards the formation of healthy habits, the following points may be indicated: personal cleanliness; household cleanliness; regularity and punctuality; temperance in food, drink, sleep, sexual indulgence; plenty of mental and physical exercise, but avoidance of mental worry and great bodily fatigue; care in obtaining pure drinking water, wholesome food, and fresh air. Constant anxiety with regard to health is, however, a state of mind to be deprecated, and is not at all needed for the acquirement and practice of healthy habits; indeed it is often a consequence of ill-health and insanitary habits.

Custom

has much power not only in the formation of social habits, but in the preservation of certain habits which are known and acknowledged to be bad. People do as their neighbours do, and even seem to think as their neighbours are believed to think, because they do not wish to appear singular. They would rather endure discomfort and possibly disease than face the scorn of custom or the pointing finger of ridicule. Those who would repeal the unwritten but binding laws of custom, when they clash with the laws of health, must sometimes brave both scorn and ridicule in the first place; but they

will earn a certain reward from health and ultimately be accorded the respect and gratitude of weaker or more ignorant fellowmen.

The reform of evil social customs and training of children in good sanitary habits greatly depend upon the sound general and hygienic education of women, and any advance in this direction is to be hailed as a good presage by sanitarians. Not only the progress of household and personal hygiene, but the success attending public sanitation in any community must be in a large measure due to its wives and mothers, the presiding spirits of its houses and trainers of its children.

It may be useful just to mention a few of many objectionable customs which education and good sense should reform. Such are intemperance, including eating to excess at festivals and entertainments; pollution of water which is used for drinking, by ablution of the person and of clothes in it, and in other ways; too early and infant marriages; insanitary practices as to abstention from food; air and cleanliness connected with parturient women and new-born children; suckling children after they have teeth and can run about; deficient exercise for women; funeral entertainments; various superstitious practices common to ignorant persons of all religions, such as shutting up the rooms of sick people to keep out evil spirits; prayer and charm healing with neglect of sanitary measures for infectious and other diseases; drinking foul water from holy places.

Cleanliness

in its most comprehensive sense embraces nearly all sanitation. Cleanliness of food, air, water, soil and dwellings has been already noticed; a few lines must here be devoted to cleanliness of person.

Cleaning of the skin is particularly necessary in hot climates when the amount of watery sweat and

solid excretion and desquamation from it is considerable, the skin performing a part of the function which belongs to the kidneys and lungs in colder climates. The effect of dirt and retained excretion upon the skin is to interfere with its action, prevent the contact of air which oxidises noxious impurities, and favour the production or propagation of some skin diseases. Most persons go through the form of washing their bodies daily with water, but the cleansing effect of such ablution is often very small. Unless soap, or some substitute for it, be employed, water, especially hard water, does not readily carry off the dirt, which is usually more or less greasy, from the skin. Friction of the skin during ablution, and with a towel or cloth afterwards, greatly assists cleansing. The very imperfect way in which ablution is usually performed is shown by the extensive prevalence of itch, ringworm, and other skin affections, and the frequent occurrence of lice, fleas, and bugs on the body and clothing. Want of attention to the cleanliness of the genital organs is a frequent cause of irritation and sometimes of disease. All parts where hair grows require special care in cleaning.

The employment of dirty water for washing is one cause of uncleanness and disease. Clean water, soap, and friction are the three requisites for cleaning the skin properly.

The practice of oil-inunction after bathing, as often used by the well-to-do, is specially beneficial to thin and aged persons.

Cleaning of the mouth and teeth after every meal is a healthy custom, and serves to preserve the teeth and to get rid of remains of food and secretions which may decompose in the mouth. It is very important, however, that only the purest water, such as is used for drinking, should be employed for this purpose. In cleaning the teeth it should be

remembered that the permanent teeth have to last their owner a life-time, and that though they are coated with a very hard substance, namely enamel, constant friction with powders will wear this away. It is quite common to find that the teeth have become deeply grooved and all the enamel worn away, particularly on the left side of the mouth, by prolonged daily friction with the right fore-finger aided by some powder. This is carrying cleaning to excess and doing irreparable injury.

Cleanliness of clothing is a necessary accompaniment of cleanliness of skin. Frequent washing of inner garments is requisite. Clothes should be washed in clean water, and it is very desirable that the clothes belonging to different persons, or at all events those belonging to different families, should be kept separate, in order to prevent communication of disease. Skin diseases and small-pox are probably often communicated by clothes. The building and regulation of public washing-places would do much to promote cleanliness and prevent infection of clothing.

Clothing.

The principal object of clothing is to afford protection against heat and cold. Man, with his bare, sensitive, and porous skin requires such protection to enable him to bear extremes and vicissitudes of heat and cold, drought and damp. In cold and changeable climates clothing cannot be dispensed with; in warm and equable ones it is less necessary. The skin of persons accustomed to out-door exposure becomes thicker, harder and less sensitive —consequently less in need of clothing—than that of persons who live more in houses, are generally more fully clad, and undergo less exposure.

The very young and very old are more sensitive to changes of temperature and more liable to

suffer from congestions or inflammations in consequence of chills than are persons in middle life; young and old people therefore need especial care with regard to clothing. Young children in India are often much neglected in this way, especially in the colder climates of the hills; children of poor parents in the hills are permitted to go about all day with as little clothing as they would wear in the plains. The result is that they suffer greatly from the effects of chill, catarrhs, bronchitis, intestinal troubles and diarrhœa, and the death-rate is in consequence much higher than it should be.

The common practice of sleeping with a sheet or blanket drawn over the face is objectionable, because exhalations from the skin or possibly dirty clothes are thus inhaled. It may perhaps be of advantage in some places by preventing mosquitoes from biting.

Cotton and wool are the commonest materials of which clothing is made. Linen is very similar to cotton, and silk to wool, in physical properties.

Cotton is much less absorbent of moisture, less permeable and a better conductor of heat than wool. Cotton consequently allows the perspiration of the skin to pass through it and conducts away the heat of the skin to the cold air outside; it thus offers little obstacle to rapid cooling of the skin, and is not well suited to form the only clothing in changeable climates and when the skin is perspiring after exertion. It is, however, easily washed, cheap and durable, and well adapted for ordinary clothing in equable climates and for under-garments in all climates. Cotton has of recent years been woven much more loosely and there are several makes of cotton under-garments now procurable which have most of the advantages and few of the disadvantages of wool.

Wool, on the other hand, is very absorbent of moisture and a very bad conductor of heat, while at the same time it is very permeable to air. It is therefore an excellent material for clothing especially in cold and changeable climates and when the skin is perspiring after exertion. The chilling effect of too rapid evaporation from the skin is prevented by the absorption of perspiration by wool and the evolution of latent heat from the aqueous vapour so condensed.

The warmth felt on investing the body with woollen clothing, especially when the skin is moist, is partly due to actual evolution of heat in this way and partly to the non-conduction of heat from the body to the outside air by the wool. The disadvantages of wool compared with cotton for underclothing are its expensiveness and its not washing so well.

Impervious materials, such as greased leather and India-rubber, are useful for keeping out wet and retaining heat; but they retain the excretions of the skin and exclude purifying air, being therefore particularly objectionable in hot climates.

The colour of clothing is of less consequence than the material; but black and dark colours are much more absorbent of heat than white and light colours. Poisonous colouring matters are sometimes employed for dyeing clothes; local irritation of the skin and even general ill-health may result.

Whether red and yellow fabrics, used as hat and coat linings, actually possess value in protecting the head and body from the actinic rays of the sun, is still a matter for exact experiment and determination.

Exercise.

Disuse of muscles or other organs leads to more or less wasting of them: regular use of organs

promotes their nutrition and growth. A moderate amount of exercise is therefore essential to the healthy development of the body in youth and to its healthy maintenance throughout life.* Many ailments of persons, who, by occupation or choice, lead sedentary lives, are due to neglect of the physiological rule of exercise. Persons of inactive habits frequently eat a great deal more than they need for the work which they perform--this is one cause of disease--but no care in dieting can make up for deficient exercise. A certain amount of exercise is essential for good health.

The connection between food and work has already been considered in the chapter on food ; it only remains now to examine the other physiological aspects of exercise.

During exertion the greatest strain falls upon the heart, blood-vessels, and lungs, the circulation and respiration being largely increased. All the functions of nutrition and elimination are secondarily stimulated. Dr. E. Smith found the quantity of air inspired by a man walking at the rate of three miles an hour to be more than three times as much as was inspired by the same man lying down, and when walking at the rate of four miles an hour it was five times as much. The same observer found that the amount of carbon dioxide in expired air was increased in proportion to the work done, for instance, five grains per minute were evolved during sleep and no less than 18 grains per minute when walking at the rate of three miles an hour. Pettenkofer and Voit obtained similar experimental results with regard to oxygen absorbed and carbon dioxide evolved. As a result of exercise the appetite is increased, and the amount of food must be

* Physical training in schools is now recognized as an educational requisite of prime importance.

increased in proportion, and, since the greatest waste occurs in the carbonaceous material, this must be replaced by adding to the quantity of fat and sugar eaten, rather than of proteid.

The best exercises for health are those which bring all the muscles of the body more or less into play, such as walking, riding, rowing. Exercise may sometimes be productive of evil effects. Thus violent or too long continued exertion, especially when there has been no gradual and regular training for it, and when food is insufficient, may be very injurious. Horses sometimes die from congestion of the lungs after violent exertion : and disease of the heart and blood-vessels is more common in men who occasionally make great efforts, such as artillery men, oarsmen and athletes, than in those who practise less violent and more continuous exercise.

Training is necessary for any great or long continued exertion, in order to bring the various organs and tissues into proper state of nutrition and accommodation. Without gradual training lassitude soon occurs.

If food be habitually deficient, wasting results from much exercise. Exertion leading to fatigue, when the usual food cannot be obtained, causes great exhaustion and may produce fainting or collapse.

Drinking during exercise is necessary and beneficial ; the fluid assists in the elimination of the waste products of muscular action ; it is better to drink frequently than to take large draughts at long intervals. Drinking cold water and bathing in cold water when the circulation is excited by exercise can do no harm to healthy persons.

After exertion when the body has begun to cool, and there is some sense of fatigue, woollen clothing should be put on. It is then that cold bathing and copious cold draughts are dangerous.

Exercise may be estimated and measured in foot-tons, that is, the number of tons which would be raised to a height of one foot by the energy expended. Conditions differ so much that an exact standard cannot be laid down for the minimum amount of exercise which is necessary for the preservation of good health. A very moderate amount of exercise is represented by half a foot-ton daily for every pound of body weight, and it is doubtful if an adult could enjoy vigorous health, when taking less exercise than this. From two to three foot-tons per pound weight is a fair day's work for a labourer. A man weighing 130 lb. does 15 foot-tons of work for every mile he walks along the level. Systematic gymnastic and physical exercise in young, healthy and vigorous men leads to increase of weight and great chest development; the circumference of the latter may be enlarged by as much as 4 or 5 inches in the space of a few months.

Graduated physical exercises have of recent years been found of immense value, particularly in training recruits for armies, but to obtain the best results, they must be conducted under educated supervision, and at the same time adequate nourishment must be provided. Not only bodily but also great mental improvement follows such training; alertness, dexterity, presence of mind, and endurance of fatigue are all acquired.

"A fine physique once gained is never wholly lost," and there can be no doubt that after such a training a man is placed in a far better position as regards his power of resistance to disease than he was before. Care must be taken to develop the limbs and all the groups of muscles equally. Exercise of the upper limbs only and neglect of the lower produce an actual deformity which is sometimes seen in Indian gymnasts.

Given a fair intellect, the man who comes to the front in life is the one who is possessed of most endurance, the one who can get through life with a little less sleep than his fellows and can do hard mental work for more hours on end and for longer periods. At the end of the year he has so many days' or weeks' work to his credit, time which persons gifted with less endurance had to spend in recreation. Genius, though it may acquire notoriety, can effect little unless coupled with power to work.

In physical as in mental exercise exhaustion undoes all good and is directly productive of evil. At the present time Indian youths of the student class not unfrequently do themselves serious injury, which may result in permanent disease of the heart, by undisciplined exercises with dumb-bells and such like in their desire to emulate Sandow, unaware that their bodies, often unaccustomed to ordinary games and further weakened by long hours of reading and sometimes insufficient food, are unable to respond. No youth in ordinary health is too weak to benefit by exercise, but the amount requires adjustment to his powers.

The rapidity with which work is done is far more important than the actual amount of work with regard to its effect as exercise. A comparatively small amount of work done in a short space of time is far more exhausting and imposes a much greater strain on the heart, lungs and muscles than a large amount of work done slowly. For this reason rapid exertion is best for those who play for health and pleasure and can only give a limited time to bodily exercise, while less speed is more suitable for those who have a large quantity of work to do.

It must be remembered that severe muscular effort exhausts the nervous system as well as severe mental effort, so that a man who is in the habit of going through hard mental work cannot expect to

recuperate his nervous system by sudden physical exercise. The brain must be rested before the muscles can work properly.

Temperance.

Temperance in all things is one of the highest sanitary virtues. Intemperance in food has been already alluded to. Occasional excess in this way is less injurious than habitual excess; but the enormous eating, sometimes of unwholesome food, which takes place at wedding feasts and other entertainments, is often productive of acute illness, such as colic, diarrhœa, or dysentery, and sometimes death results.* Habitual intemperance in food causes dyspepsia, congestion of the liver, and other disorders which predispose to various diseases and are productive of much discomfort and materially shorten life.

Intemperance in drink is generally confined to alcoholic liquors. Habitual drinking of raw spirit, a vice increasingly prevalent in some places, is the worst form of such intemperance. Diseases of the liver and blood vessels are common results of this form of intemperance. As has been already said in the Chapter on Food, the drinking of alcoholic liquors, even in small quantities, is a dangerous luxury; excess is not easily avoided, and, as a matter of fact, nearly all those who do take them at all do sometimes, if not frequently, take them in injurious quantity. It is in the experience of nearly every physician that "strictly temperate" persons, that is persons who are never even slightly intoxicated do not rarely suffer from drinking too much alcohol. Statistics of friendly societies and of insurance offices distinctly prove that "total

* Some cases which reach the Chemical Examiner can scarcely be attributed to any other cause.

abstainers" from alcohol suffer much less from disease and live much longer than "moderate drinkers."

The practices of smoking opium or ganja and of eating them in sweetmeats or otherwise are very prevalent in some parts of the country and are hardly less noxious than drinking alcohol to excess. The action of these drugs is unfortunately too well known to need description. The wretched condition, mentally and bodily, of persons who indulge in such practices, and the not uncommon commission of crimes during the delirium produced by ganja, ought to deter others from indulgence in them. Tobacco smoking is much less injurious and in most cases it is practised with no very obvious injury to health.

Mental Hygiene.

Mental education and soundness have great influence upon development and health. There is much evidence that the mental impressions of a pregnant woman may affect the development of the fœtus in her womb. The secretion and quality of milk is also affected by mental emotions. It is notorious that anxiety, care, disappointment, and all depressing emotions, have a very injurious effect upon health, while a contented and self-controlled mind is conducive to good health. It is therefore most important that healthy habits of mind should be cultivated. There is necessarily constant action and re-action between the brain and the rest of the body; ill-health has an injurious effect upon the brain as upon other organs, and unhealthy action or disease of the brain re-acts upon general health.

Healthy development and maintenance of the brain, as of other organs, are promoted by moderate, regular, intermittent exercise. Training increases its capacity for work within certain limits; but

and because too early consummation of marriage is encouraged by it.

The question of early marriage, looked at from a purely physiological point of view, is easily disposed of. The effect of cohabitation at too early an age, before the physical development of the body is complete, is very injurious in both sexes. It prevents full and strong physical development of both, causes a lack of manliness and energy in the man, and exposes the immature woman to danger in child-bearing. The children of very youthful parents are probably less vigorous than those of matured parents: a mother who has to provide for the growth of her own body as well as for that of the child she is bearing is likely to starve both. It has been urged in favour of early marriage that the suppression of an important physiological function must be prejudicial to health, and, on this ground, marriage should take place in both sexes at puberty; but it is a matter of common experience to many besides physicians that sexual indulgence before bodily growth is complete, is disastrous to health.

The mortality of the married under 20 years of age has also been shown by statistics * to be excessively high in both sexes. It must therefore be concluded that early marriage, that is, marriage before growth and bodily development are complete, is decidedly injurious to health.†

The question of early, in the sense of improvident, marriage has important bearings for the philanthropist, the political economist, and the sanitarian, which can be only briefly alluded to here.

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* French vital statistics quoted by Farr.

† "Manu wishes a young man to marry when he may become a Grihastha, *i.e.*, when he is about 24 years of age. As to the girl she is to marry when she is fit for it."—*Max Müller* (letter to Mr. B. M. Malabari). As we have pointed out a girl cannot be considered really fit for marriage and the exhausting duties of maternity until her growth is complete.

In countries where early marriage is a prevalent custom, not only are marriages more numerous, but the number of children born to each marriage is much larger than in countries where marriages are usually contracted later in life, with a more prudent regard for the means of rearing progeny.* One result is that in populous countries where improvident marriages are the rule, the population tends to increase in a more rapid ratio than the means of subsistence, and it is naturally reduced by the "misery check" † of famine and disease. In those countries, on the other hand, where later marriages regulated by prudential considerations regarding the support of children are the rule, the population increases more in proportion to the means of subsistence and is less liable to be thinned out by famine and disease. The voluntary "prudential check" to population, in the shape of provident marriage, is therefore often a wise and efficient provision against misery and disease. It has been argued that an early marrying race or class must "breed down" and supplant a later marrying race or class.‡ But there is a great fallacy in such an argument, the conditions are dissimilar. The more prolific early marrying race may, and is likely to be, less provident, less vigourous, less wealthy, and consequently much more affected by the "misery check" than the later marrying race who adopt the voluntary "prudential check." The same rule applies to individual families; the offspring of the more prudent and well-to-do is less subject to the

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* Dr. Mathews Duncan gives the following returns from the Lying-in-Hospital of St. George's in the East:—

Age of mother at marriage ...	15 19	20 24	25 29	30–34
Average fecundity	9·12	7·92	6·30	4·60

India may be taken as an example of a country where improvident marriages are the rule; in England, on the other hand, statistics show that the marriage rate is influenced by prosperity and means of subsistence.

† Malthus.

‡ *See* Inquiries into Human Faculty, by F. Galton, 1883.

"misery check" than that of the less prudent and very poor.

It has also been advanced that in a rapidly-breeding race improvement takes place by "survival of the fittest." The fittest under such circumstances, however, would be the fittest to exist under depraved conditions; and it can hardly be doubted therefore that early and improvident marriage and too rapid breeding are to be condemned on evolutionary principles as tending to degrade the race.

All these considerations indicate unmistakably that not only infantile marriages but all improvident marriages are fraught with evil to the family and to the race. No sudden change of social habits is possible, but it is a question of deep concern for all thoughtful and influential persons to educate gradually the masses to truer conceptions of the responsibilities and consequences of marriage.* Unfortunately the very poorest classes are the greatest offenders, as they are also the greatest slaves of custom, in this respect.

In comparing the circumstances of this country with those of other countries where more provident habits prevail, the effect of early marriage on population and mortality should not be lost sight of by sanitarians and administrators.

Postponement of marriage limits the child-bearing period and a lowered birth rate naturally follows. In India no postponement is likely to occur which would react in this way, at any rate sufficiently to depress the birth rate appreciably. When marriage is limited to parents of full age, even though fewer children may be born, fewer die both actually and relatively as they are better cared for,

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* Little advance can be expected in morality until the producing of a large family is regarded in the same light as drunkenness or any other physical excess."—*J. S. Mill.*

so that at the same time the infantile death rate is lessened.

The inter-marriage of blood-relations is often objectionable because their progeny has a double chance of inheriting any weaknesses or tendencies to disease which are common to their ancestors. A neurotic temperament or tendency to disease (including mental disease) is likely to be thus transmitted or increased.* On the other hand if the stock be a vigorous and healthy one, the inter-marriage of relations may increase some desirable family qualities.†

Several diseases and tendencies to disease are hereditary. The marriage of persons actually affected with hereditary disease, such as syphilis and probably leprosy, should be discouraged as an immoral act fraught with evil to their offspring and tending to disseminate disease. The inter-marriage of persons affected with or who have a family tendency to certain diseases such as tuberculosis, rheumatism, gout, insanity is also to be discountenanced, because the children of such inter-marriage would have a double chance of inheriting the diseased tendency.

This subject cannot fitly be concluded without saying a few words upon the evil consequences of sexual abuses. The effects of venery in the young have been alluded to under the head of early marriage. Excessive sexual indulgence is very injurious in adult life, but doubly so in youth; it produces general nervous depression with mental and muscular weakness, and results in premature loss of sexual power, early ageing, and sometimes in actual disease of some part of the nervous system.

* *Cretinism* has been attributed to breeding in and in in small isolated

Over indulgence in married persons is often the result of ignorance, and in the unmarried it is encouraged by the stimulation of lewd companionship, obscene literature, and the lures of prostitution. Notwithstanding the custom of early marriage, various forms of sexual depravity occur among youths in this country, and it is a manifest duty of parents or guardians of children to explain to them, as soon as they reach the age of puberty, the nature of, and the dangers to health attending, such practices. They cannot be brought up in ignorance of sexual passion, and the sooner they are instructed in the mystery of sexual physiology and have explained to them the necessity of controlling this passion and the danger of its abuse, the easier will it be for them to avoid the rocks which beset the path of ignorance. Healthy exercise of body and mind, unstimulating diet and chastity of thought render continence easy. There is no danger in continence but great danger in excess, and everything which stimulates the sexual passion may be a source of danger to health.

Maternity.

The health of pregnant women needs special attention not only for themselves but for the sake of their offspring. Unwholesome or insufficient food, excessive work, and depressing mental emotions or violent excitement are often more injurious to the offspring than to the mother. During the great famine of 1877, mothers who did not themselves exhibit any great bodily wasting often gave birth to extremely emaciated and evidently starved infants; a generous diet is therefore necessary for pregnant women.

During and after child-birth, cleanliness of person, free ventilation of the lying-in room and a

sufficiency of wholesome food for the mother must be provided.*

The prevalent custom of suckling children until they are three years old is injurious to the mother as well as to the child. The effect of prolonged lactation is very exhausting to the mother and useless to the child. A child ought to be weaned when about 9 months old. A nursing mother requires almost as much care and nourishment as a pregnant woman: bad food, excessive work, or mental emotion may interfere with lactation or cause the milk secreted to be of injurious nature.

The milk of underfed women is poor in fat and especially in proteid, though the sugar is above the average. It may be quite unfit for infant food. Average analyses of human milk gave the following percentage results: —

—	Fat.	Sugar.	Proteid.
European women	3·8	6·2	2·3
Poor class Filipinos in Manila ...	3·07	7·98	1·29

The Four Ages of Man.

The lifetime of man may be divided into the four periods of infancy, youth, maturity, and old age.

The well-being of an infant depends almost entirely upon its mother. Infants should as a rule be suckled by their mothers, a foster-mother is, however, desirable when the mother is very feeble or is affected with some disease, such as tuberculosis, which may possibly be communicated to the infant.

If a child has to be reared by hand, cow's milk should be its only food. This may be secured in

* The native mode of treatment of women in accouchement is one of peculiar hardship and torture to the patient. Kanny Lall Dey: *Hindu Social Laws and Habits.*

a perfectly healthy condition if the cow be milked in the presence of some responsible person who makes sure that the teats of the cow, the hands of the milker and the receiving vessel are all clean. The cow should have calved not less than 5 weeks and not more than 5 months previously, otherwise the milk will be unfit. The milk when thus supervised should be administered to the child unboiled: it should only be boiled if there is doubt as to its cleanliness. No milk given to an infant should be more than 12 hours old.

To render cow's milk digestible to an infant, it should be diluted to one half with boiled, cooled water, during the first month of life, afterwards the proportion of milk to water may be gradually increased, till at 4 months, a healthy child is taking undiluted milk. About 3 teaspoonfuls of sugar should be added to the milk during the 24 hours, and to prevent too firm a curd from forming in the stomach and giving rise to dyspepsia and colic, 0·5 per cent. sodium citrate should be also added. The latter is most important. Patent foods need scarcely ever be used. If there be any doubt the milk ought to be boiled. It is a common fault to feed infants too frequently, over-fed infants often cry because they suffer from indigestion and not because they want food. They should not as a rule be fed more frequently than at intervals of 3 hours, so that the digestive organs may have some period of rest. Weaning should gradually take place as the teeth appear, or when the infant is eight or nine months old. Small quantities of gruel may be given at first, and by degrees this may be supplemented by some easily digested solid food. The practice of distending the stomachs of infants and young children with large quantities of food such as is taken by adults is strongly to be reprobated. Large quantities of sweetmeats are objectionable, and

highly-spiced articles of diet should also be avoided. Young children require to be fed more frequently than adults and (as explained in the Chapter on Food) need relatively a larger quantity of food. The giving of opiates or stimulants to children need only be mentioned to be condemned.

The cleanliness of infants and children is too often neglected. When they are washed it is frequently by pouring cold water over them in a current of air, a likely method of inducing internal congestions. Immersion in water or at all events protection from wind during ablution, and rapid drying by friction with a cloth is the proper practice.

No clothing is commonly worn by infants and young children in Southern India and they not rarely suffer from exposure to vicissitudes of temperature. It should be borne in mind that children are more sensitive to changes of temperature and possess less vital resistance than adults, consequently they need more rather than less protection.

The care of young persons during youth, the period of active development and growth, and the due inculcation at this time of habits of self-control and cleanliness, are matters of the highest possible importance which have been previously alluded to and need scarcely be further insisted upon here. The attention which is now being paid to physical culture in our schools is a step in the right direction and one which deserves further extension.

The period of adult life may be regarded as extending from the time when growth is complete, that is, between the ages of 20 and 26 years, to the time when decay begins, that is, in healthy persons, between the ages of 40 and 60 years. This is the period during which the bodily powers are in

the highest state of development and activity, but the mental powers do not generally attain their full ripeness till towards its close.

In old age the hair becomes grey or white, the sight and hearing become less acute, muscular and digestive powers diminish, sexual power declines, fat under the skin becomes absorbed, the skin becoming less elastic and more dry and wrinkled, the bones become hard and brittle, and the tissues of the body tend to degenerate. Old persons require more digestible food, warmer clothing and less work than adults.

Vitality and Longevity.

It is notorious that some individuals are much more apt than others to contract disease, and they succumb more easily to it or recover more slowly and less perfectly. The vitality of such persons is low and they are as a rule short-lived. Others, on the contrary, do not readily contract disease and they recover from it more rapidly and perfectly. Such persons possess a high degree of vitality.

Vitality may be partly inherited and partly acquired. Healthy, vigorous, and long-lived ancestors tend to produce healthy, vigorous, and long-lived descendants. Healthy rearing and physical education of children have much influence in increasing or preserving their natural vitality; and throughout life, hygienic surroundings and habits affect the vitality of individuals in a favourable manner. On the other hand, all unhealthy surroundings and habits affect vitality unfavourably. Excesses of all kinds, such as in eating, in alcoholic drinks, and in venery, exert a powerful depressing influence. Most long-lived persons are of moderate habits, a little above average height, and of rather

spare condition.* From all the evidence we possess, it must be inferred that, although vitality is in part an inherited quality, yet it is to a large extent within the power of individuals themselves to increase or reduce their own vitality.

Long life and good health are as much due to good vital resistance, whether hereditary or promoted by hygienic personal habits, as they are due to protection from exposure to disease. If the tissues of the body possess a vigorous life of their own, disease microbes cannot readily destroy or grow upon them and they will recover rapidly from various causes of depression or irritation which would impair or destroy tissues of lower vitality. To afford protection from exposure to disease is the main function of Public Hygiene, to increase vital resistance to it is mainly one of Personal Hygiene.

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* *See Report on Aged Persons* (Collective Investigation Committee of B.M.A.) by Professor Humphry, F.R.S. *British Medical Journal, March* 10, 1888.

CHAPTER IX.

REMOVAL OF WASTE.

Nature of Waste.

The constituents of the waste of human habitations are (1) *latrine waste*, comprising excrement, urine, and washing water; (2) *kitchen waste*, consisting of refuse portions of vegetable and animal food, washings of cooking vessels, and ashes; (3) *house waste proper*, general house sweepings and bath water; (4) *stable waste*, excreta of domestic animals and litter. Town councils also have to provide for the removal of (5) *factory waste* and (6) *street sweepings*. The refuse of slaughter-houses may be treated as latrine waste. All these substances have to be speedily removed and suitably disposed of in order to preserve the purity of soil and air in and about dwellings and to prevent contamination of water. Such removal and disposal is one of the most important duties of executive sanitary authorities and one upon which the health of the people principally depends.

Diarrhœa, febrile attacks, general ill-health and sore-throat are the most common and general results of exposure to emanations from foul sewers or accumulations of decaying organic matter. Such emanations also increase the liability to attack by specific diseases by depressing vital resistance.

Liquid waste of all kinds, whether including urine and ordure or not, is termed *sewage*, and the channels by which it is removed are *sewers*. Drains,

of which the primary use is to carry off water from the surface or from the depth of the ground, are occasionally used also for conveying sewage, and thus serve a double purpose.

We may compare a town with the human body. Each produces a quantity of waste matter daily, which has to be got rid of, or health declines. The carts which remove the solid refuse from a town play the part of the bowels of the human body. Failure to remove town refuse has as bad an effect on the health of the community as chronic constipation has on the health of the man.

Drains and sewers match the kidneys and urinary passages. An obstructed drain leads to symptoms in the community which may be likened to retention of urine in the man, and a leaky drain poisons the sub-soil, just as extravasated urine poisons the tissues of the man.

In olden times the remedy adopted to avoid self-poisoning by the accumulation of excreta and organic refuse round dwellings was migration. Gregarious animals also from time to time migrate for a similar reason. Our manner of living is now-a-days too complex to permit the removal of residences from polluted areas, so we have to remove the refuse to prevent pollution.

The waste matter which has to be disposed of may be conveniently considered under the headings of street sweepings, excreta and sewage.

Collection of Refuse.—The composition of house refuse and street sweepings differs in different countries and towns: it always contains much putrescible matter which becomes offensive in a few hours when the temperature is high. It should, therefore, not be heaped up in a yard adjoining the house for days together, nor be allowed to lie about in the streets.

Whether it be in a town or in a populous village, the ideal system is for each house-holder to collect his refuse in a moveable metal receptacle, which can be emptied twice daily by a public service of carts. If the women of the household simply throw their refuse outside into the street, it is blown about by the wind and sorted by animals, and endless trouble is given in sweeping it up, not to mention the danger of possibly infected matter being spread about. Public dust-bins are necessary in busy parts, but they cannot altogether take the place of private ones, and there is frequently a difficulty in finding a suitable site for them.

The pattern does not matter; all that is required is that a dust-bin should be of non-absorbent material and so constructed that it can be easily and completely cleaned. Where there are no private dustbins, one public one to about 110 people will suffice.

Rubbish carts should be covered in to prevent their contents being blown about as they traverse the streets. Ordinarily one rubbish cart, carrying ½ ton and working two trips daily, will serve 1,200 people. In towns 1,000 persons will afford from ½-1 ton of rubbish per diem, or from 25—40 cubic feet.*

Disposal of Refuse.—After collection there are two ways open for disposal, (1) Dumping, (2) Incineration. Theoretically the proper way to get rid of rubbish is to dig it into ground under cultivation where it becomes disintegrated and enriches the soil. Practically, however, difficulties often prevent this.

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* These figures were calculated from measurements made in a part of Madras in 1900. Taking the whole of Madras, approximately 12½ cubic feet,

Dumping or filling up low ground and reclaiming useless land, is sanitarily unobjectionable, provided that the place is one far removed from habitations, and pollution of the air and soil for the time being do not much matter; but difficulties often arise on account of the expense of transport. On no account should tanks, old wells, or low ground near inhabited areas, or where there is any danger of polluting a water-supply, be filled up with rubbish. To prevent smell from a rubbish heap and the development of too many flies, the sweepings should at once be covered over with a layer of earth or silt 6 inches deep. An old rubbish heap must not be built over until the organic matter has been completely destroyed. This may take 5, 10, or even 20 years according to circumstances.*

The only sure test is to dig a hole and examine the condition of the soil down to the bottom of the deposit.

Nothing will grow on fresh rubbish heaps, and trees which are growing close to one may even be killed. After six months, grass and shallow rooted plants may profitably be put down. Indian rubbish contains nothing of value. Crows and dogs and buffaloes devour everything eatable before it leaves the streets, and the people never throw away anything that can be sold. In England rubbish is sorted; tins and old iron are removed for melting down, paper and rags for making into paper, bones for manure, and so on. Enough wood, coke and coal dust are found mixed with it, not only to enable it to burn readily, but to supply enough heat for running machinery.

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* Examination of a rubbish heap 20 years old in Madras in 1900 showed numerous, recognisable, organic elements of the dust-bin. This heap was over 20 feet thick, high, well drained and dry, and disintegration had evidently proceeded very slowly.

In India the quality of the rubbish is often such that it will not even burn itself without added fuel. In spite of this fact, in the larger towns the expense of transport to a distance and the lack of suitable dumping grounds have rendered it necessary to resort partially, at any rate, to incineration. Whenever it is possible, it is better to carry rubbish out of a town by a light tramway or railway to the dumping ground. In some places rubbish is carried out to sea in barges and tipped overboard where the currents and tides will carry it away from the inhabited shore line. Indian street sweepings, it must be remembered, can never be treated as comparatively harmless matter, as a variable quantity of human excreta is nearly always mixed with it.

Incineration or destruction by fire is for most large towns the safest and, in the long run, the cheapest way of getting rid of rubbish. A description of *rubbish destructors* or *incinerators* would be out of place in this manual: it need only be remarked that if carefully constructed and managed, they can be situated in the heart of a town without sanitary offence, that the rubbish that passes through them is rendered perfectly innocuous, and that the resulting ashes can be applied to a variety of useful purposes.* Small incinerators of the bee-hive and other patterns, which have no provision for inducing a good draught, are useless except for burning the refuse in the compounds of hospitals, jails, and other institutions. They might, however, serve a useful purpose in small villages of under 1,000 inhabitants, if the people could be persuaded to keep them going. Large incinerators, even in Europe, sometimes are expensive to work, owing to the incombustibility of the rubbish, and this is a still greater source of

* In 1904 the rubbish burned in the Madras incinerator produced 33 per cent. of ash.

trouble in India. Additional difficulties are caused by the saturation of the rubbish in the rainy season. Necessary adjuncts to an Indian incinerator are a well covered shed to keep the collected refuse dry, steam blowers to increase the draught in the furnaces, and skilled feeding and stoking. The successful working of the whole plant depends on the experience and intelligence of the firemen. The products of combustion must be passed over the incandescent fires to prevent noxious vapours and gases from being discharged into the atmosphere.

EXCRETA.

Quantity. Solid.—Meat eaters, adults about 4 ounces daily; vegetable eaters, adults 8–16 ounces daily; women and children less.*

For a mixed Indian community, 8 ounces per head per diem is not too much to base a calculation upon.

Liquid.—From 35–45 fluid ounces of urine daily. When fresh, fæces are usually acid; on decomposing they become alkaline from the formation of ammonia. If kept dry and free from urine or water, fæcal matter decomposes slowly, but when mixed with urine, both decompose rapidly. The highly nitrogenous excreta of carnivora are more offensive than the slightly nitrogenous excreta of herbivora.

It is a significant fact that many species of the former, *e.g.*, cats, tigers, cover their dejecta with earth, whereas the latter never do so.

Collection of Excreta.—In towns which possess no sewerage system, it is even more important that adequate arrangements should be

* From collections and weighments made from a public latrine in Madras in 1900.

made for the removal of excreta from public and private latrines once, if not twice, daily, than it is to organize the collection of street sweepings. In private houses excreta are deposited either in pits in the ground or in some form of receptacle, or on a cemented surface. Removal from pits is only performed at intervals when the pit is filled, pails and cement latrines are cleaned daily.

The term "conservancy" should, strictly speaking, be applied only to those systems in which excreta are removed by hand, *e.g.*, pail, dry earth, and midden or pit systems. Most sanitarians are now agreed in looking on these as wrong in principle and only make-shifts. Our ideal should be to get all excreta as far away from habitations as possible with the utmost expedition, and this is best attained by water carriage. A great argument in favour of the water carriage system in India is that when it is in operation the populace is less at the mercy of that very intractable community who are variously entitled bhangis, halalkhors, toties and mehters, and who can be influenced by nothing but the rod, which it is not legal to apply. As far as towns are concerned, every house-holder who can afford one should have a latrine on his premises, and the Municipality should provide a sufficiency of public latrines for the use of the dwellers in bastis, parcheries, hutting grounds and the like. Until this is done, persons who defæcate in byeways, ditches, and on waste land, cannot with justice be prosecuted.

All systems which involve the retention of fæcal matter on the premises, whether in towns or in villages, must be condemned without reservation, whether the excreta be dropped into deep pits or mixed with earth in a hole. The soil is polluted and the wells become so contaminated that the water may even be too brackish to drink, and the odour

in the houses is sometimes overpowering to one who is not accustomed to it.

If it be absolutely necessary to choose between a pit, pail, or cement latrine for a private house, choice should fall on the pail or moveable receptacle pattern, for the receptacle can be thoroughly cleaned and all its contents taken away from the house, whereas it is impossible in the absence of drains to keep a cement surface clean. If a pit be the pattern in use, it must not be a mere hole in the ground, the contents of which soak into and pollute the soil, but it must be properly built and lined with impermeable material and of small size, not more than 8 cubic feet in capacity, necessitating frequent emptying.

It is best that the collection from all private latrines as well as the public ones should be made by scavengers under the control of the sanitary officials: privately engaged scavengers, whose function it is to carry excreta buckets to a public cart or depot, are apt to consult their own convenience rather than perform a troublesome journey. There is no need to dwell on the various types of cart and bucket employed for carrying excreta; no pattern yet designed is free from disadvantages and, if there is any choice in the matter, the simplest pattern should be selected, as mechanism of any kind generally fails in its object when scavengers have anything to do with it.

By the *dry earth system* is understood the separation of the urine and fæcal matter and the admixture of earth with the latter, the urine being separately removed, or the addition of a sufficiency of dry earth to both urine and fæces to soak up all moisture and prevent any odour. The system aims partly at keeping the matter dry and retarding putrefaction till it can be removed, which is equally well performed by ashes or powdered charcoal,

and partly at starting the nitrification of the organic matter at once by mixing it with an earth rich in nitrifying organisms. Earth which is used for this purpose must be dried either in the sun or by gentle warmth only. If overheated it is sterilised, and all the nitrifying bacteria are destroyed and the earth becomes as inert as ashes or charcoal.

Antiseptics and deodorants should never be thrown over mixtures of fæces and dry earth : the nitrifying organisms are destroyed by them, and the very process which it is desired should take place is checked.

On a small scale when managed by people who understand it, the system works exceedingly well; the mixture is carted away and the fæces rapidly nitrify, and then the same earth can be used again many times. On a large scale, difficulties of transport and supply of dry earth render the system inapplicable. There is nothing, however, in dry earth to destroy pathogenic organisms, and it has been pointed out that in towns which used this system the number of attacks of typhoid fever was greater than in others which had water carriage.

Disposal of Excreta.—The next point is how, in the absence of a sewerage system, can excreta, collected in carts from public and private latrines, best be disposed of? The object in view should be to utilise as far as possible the stuff as manure. Incineration which is practised in some places on a small scale is both expensive and wasteful; it should be confined to hospitals where it is necessary to completely destroy the excreta in the case of communicable diseases such as typhoid and cholera.

In other places the excreta are mixed with ashes, obtained by burning rubbish, and turned into *poudrette* which in places is said to command a

ready sale as manure. The tastes of cultivators, however, vary in different parts, and in the Madras Presidency poudrette is not fancied. Cultivators will rarely take fresh night-soil for manure ; they prefer it to be matured for several months. Objections to this method of making poudrette are that a somewhat large area is required for the mixing and drying processes, and that it can only be carried on in the dry season.

In some places the collected excreta are artificially dried in a closed apparatus and the ammoniacal fumes evolved are fixed by passing them over sulphuric acid. The dry material is much less in bulk than the original, and has some value as manure, but the process requires a steam plant and is too expensive to pay its way.

The most widely adopted method is "*trenching*," and this if properly carried on gives eminently satisfactory results. When night-soil or any other organic matter is put below the surface of the ground, putrefaction with the evolution of foul smelling gases is arrested, and a class of bacteria, which are found in the soil and are known as nitrifying bacteria, grow in it and change the complex nitrogenous organic matter into simple nitrates, and turn it into fit food for plants. This process is most active in the upper layers of the soil where oxygen is most plentiful ; the deeper the burial the fewer bacteria, and the slower the process of nitrification. Trenches, therefore, for night-soil should not be more than one foot deep and not more than 9 inches depth of night-soil should be put in them.

All the earth which was removed from the trench should be broken up as finely as possible and then thrown on to the top of the night-soil.

The ground must be of a light, porous nature, so that moisture is rapidly absorbed, a clay soil being

most unsatisfactory. Care must be taken in selecting the site, so that there is no possibility of contaminating a water-supply. It often happens that a sufficient area of suitable ground is not available within a reasonable distance and the trenches are made too deep and too much night-soil is buried in each. Retardation of the process is the result.

Under the usual conditions of trenching in India most of the fæcal bacilli die off in 2 or 3 years, and the longer the night-soil remains in the ground, the fewer the species that persist. Pathogenic organisms, such as those of cholera and typhoid, are more delicate and less resistant than most of the saprophytic organisms and do not survive very long.

A plot of land one acre in extent will suffice for the excreta of 4,000 persons for 315 days, if trenches 20 × 3 × 1 feet are used, leaving 3 feet between each.*

Under favourable conditions complete disintegration of the contents of the first trenches will have taken place at the expiry of this time, and the land can be used over again, the second lot of trenches being cut at right angles to the first.

It is advisable to allow twice as much land as is absolutely necessary and to let it lie fallow as long as possible. If sufficient land be available, it is a good thing to thoroughly plough up and grow a crop on the trenched area before using it again. A trenching ground, however spacious and well conducted, is bound to be more or less of a nuisance on account of the smell while carts are being emptied, and it may also be a breeding ground for myriads of flies. The only way to prevent flies from breeding is to have a sufficient thickness of well powdered earth, not less than 6 inches, spread over the surface

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* Calculated from experiments made at the Mylapur trenching ground, Madras, 1899—1903.

of the trench. If 9 inches depth of liquid fæcal matter be poured into a trench 1 foot deep and the dug-out earth be powdered and spread over it, about 6 inches of earth will sink into and be absorbed by the fæces and the remaining 6 inches will lie clean and free on the surface. Flies cannot penetrate such a layer to lay their eggs in the fæces.

Arrangements should always be made at a trenching ground for washing and disinfecting the carts before they are allowed to return to the town.

In wet weather difficulties frequently arise, and probably the best way out is to store the contents of the carts in a large covered cemented tank until the worst of the rain is over. The contents of the tank can then be pumped out into trenches. The chief disadvantages of the trenching system are the distance carts have to go from inhabited areas, owing to the difficulty of acquiring suitable plots of land within easy reach ; the smell arising from the carts as they pass along the roads ; the spilling of their contents on the roadway, and the spread of infectious disease by flies feeding on excrement clinging to the carts as they pass along.

Trenching is not, therefore, a system to be recommended for adoption by towns which can afford a water carriage system.

Sewage.

Sewage is the term applied to waste water which also serves as the vehicle for the carriage of excreta. *Sullage* is the name given to the waste water from dwellings, which is unmixed with excreta. In towns in which the excreta are removed by hand, the problem of dealing with the sullage water remains to be solved.

Collection of Sewage.—In towns, and villages too, the disposal of waste water is a serious problem.

Naturally, the more abundant the public supply, the more waste there is to be removed, and there is least water wasted in those towns which have no pipe water-supply. When every drop of water has to be fetched from a distance, or bought, or drawn up from a deep well, people are extremely careful of it. In a town which has street fountains, a cooly will not hesitate to expend 20 gallons in sluicing his legs and will often omit to turn off the tap when he moves on, nor will the policeman standing by or any rate-payer think of repairing his error.

In the mofussil, and more particularly where each house stands in its own paramba as in Malabar, many house-holders should be able to dispose of their organic refuse by incineration and burial, in accordance with the principles laid down above, not only without sanitary offence but with advantage to their gardens. Waste bath and cooking water is, under these circumstances, best dealt with by irrigating the garden plants, care being taken to prevent the formation of pools and small swamps anywhere. If there is too much water for surface irrigation it may be allowed to run along unjointed earthenware pipes laid not more than one foot below the surface. It is then rapidly purified by nitrification and does not render the surface damp. Care must be taken to avoid introducing quantities of foul water into the sub-soil some feet below the surface where the nitrifying organisms are few. It is easy to contaminate the sub-soil water, and any well near, in this way.

In towns where there are no gardens, it becomes necessary to have some system of drains to carry away the liquid waste of houses. Where drains do not exist, each house has to have an open *catch-pit* in front, which is bound to be a nuisance, or else an underground *sink-pit*. If the sides of these pits be pervious, the sub-soil is fouled to such an

extent that the wells sometimes become too brackish to be used; if impervious, difficulties are always arising in connection with the regular removal of their contents. Such systems have nothing to recommend them.

The next step in evolution is the *open side drain* which carries sewage and storm water. When these are not constructed in such a manner as to prevent soakage into the soil and with sufficient fall to carry away the sewage rapidly, they are hardly an improvement on catch-pits and sink-pits. Even when made in cement with the approved oval section, extended experience, as in Madras, has shown that they work by no means satisfactorily. Their great advantage was supposed to be freedom from smell, owing to the immediate dilution of any foul gas formed in the open air. Really, they cause constant complaints by reason of the smell evolved, and space will not permit an enumeration of their other disadvantages.

If sullage water be collected in catch-pits or sink-pits, these receptacles have to be emptied at frequent intervals into watertight carts which convey the liquid to some rubbish depot or trenching ground for disposal. Expense always makes it difficult to maintain a sufficient supply of carts for this purpose, particularly in towns in which the houses have a pipe water-supply. If large, underground, cemented sink-pits or cess-pools are the fashion, these are best emptied by a hose and pump attached to the cart.

The *separate system* of drainage and sewerage provides for the removal of sewage in small well-made sewers, while storm water and drainage generally is carried off by large drains which need not be so carefully nor expensively constructed. The advantages of this system are that the sewers are

very small and proportionately inexpensive; they are not so liable to be blocked because the quantity of sewage is tolerably constant and silt conveyed by storm water is excluded; the sewage is more highly concentrated and therefore more valuable as manure; while the drains need not be watertight and will consquently be more efficient for sub-soil drainage.* The *combined system* of drainage and sewerage provides for the removal of drainage and sewage together in large sewer-drains which are expensive to build and maintain, while their large size is a disadvantage except during rain; they are likely to become blocked by deposits of mud and sand, and unless leaky they are of little or no use as sub-soil drains.

Under-ground Sewers, though they have certain disadvantages such as leakage through faulty joints and cracked pipes, which, all unknown, may foul the sub-soil and contaminate the pipe water-supply, possess advantages which far outweigh them. Not the least are the possibility of the water transport of excreta, and the direct connection with house drains which prevents much mud and detritus entering the sewer. When houses are not fitted with water-closets it is quite unnecessary to insert intercepting traps in each house connection, a disconnection outside the house is sufficient to allow any sewer gas a free exit, and this may be ensured by the addition of a ventilating tube. In few places in India can it be safe to expect sewers to carry all the storm water as well, but, owing to the structure of native houses, the drainage from courtyards and roofs during heavy rain will find its way through the house drain into the sewers and augment the total volume of sewage considerably.

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* This important advantage, especially in malarious places is too commonly lost sight of.

This cannot be helped and is perhaps no great disadvantage, but the ordinary surface washings of roadways and open ground generally should be otherwise provided for by storm water ditches leading to a convenient outfall. A working knowledge of gradients, pipe laying, construction of sewers, material for pipes, forms of traps, water-closets, ventilating shafts, manholes, inspection chambers, cleaning apparatus, etc., is essential for any one engaged in practical sanitary work, but descriptions of these things cannot find a place here.

The Water Carriage System.—Much has been heard of the inadvisability of thrusting innovations of western origin on an eastern community whose customs and prejudices are not in harmony with them, but there is no reason why, when due modifications have been introduced, an up-to-date system of sewers should not work as successfully in India as in Europe and carry excreta as well as dirty water. Even though custom and poverty forbid the establishment of water-closets in native houses, the collection of excreta in the usual way in carts and pails may go on, and, instead of having to be transported through miles of streets, their contents may be delivered at convenient stations and forced into the sewers under pressure as is now done in parts of Karachi and Bombay and will shortly be done in Madras. But it is in connection with public latrines that the water carriage system is of inestimable advantage. They cease, when connected with sewers, to be a continual source of offence to the neighbourhood and a nightmare to the conservancy department.

Disposal of Sewage.—Sewage collected in catch-pits must be daily removed in metal tank carts. The method of ladling it out in buckets leads to great offence, and entails the spilling of a quantity

on the roadway. It is far better, when it can be afforded, to pump it up into the cart through a hose let down into the liquid. The sewage is then best disposed of by irrigating a plot of land set apart for that purpose, on which grass or vegetables are grown. Under no circumstances should untreated or crude sewage be discharged directly into the sea, a river, nullah, or tank. It must be remembered that the sewage is of high manurial value and that it is the duty of the local authority to make the sewage pay for the cost of its collection, and at the same time to enrich the community by improving the producing power of the land under cultivation.

Silt and deposits removed from silt traps, manholes, and sewers, should be at once removed to a suitable dumping ground. The practice of leaving such matter by the roadside for the water to evaporate to save cost of cartage is sanitarily incorrect.

No sewer or drain should pass beneath a house or building where it is impossible to examine it in case of leakage. It must not be forgotten that decomposing sewage evolves combustible gases and that it is often dangerous to carry a naked light into a newly opened manhole, old drain, or cess-pool. Careless coolies are not unfrequently seriously injured by explosions under such circumstances. Either a Davy's lamp should be used, or time given for the cavity to be thoroughly ventilated. The air in old drains and cess-pools may contain poisonous gases and persons entering them may lose consciousness or even die. In less concentration these gases give rise to vomiting, diarrhœa and prostration. Long exposure to air contaminated with emanations from sewers or cess-pools, though it may not cause definite disease, leads to a lowered vitality and, consequently, predisposes towards disease in general.

Purification and Utilisation of Sewage.—Our object is so to treat sewage that the effluent or resulting liquid that flows away, if not all required for irrigation, may be safely discharged into any water course, and at the same time to endeavour to make the process pay for itself in the way of manurial value obtained. Two methods are adopted, sometimes separately, sometimes in combination, (1) Chemical, (2) Biological.

The *chemical processes* have for their object the precipitation of the solid constituents of the sewage. This is effected by the addition of lime, alum, protosulphate of iron, or some other chemical to the sewage in settling tanks.

From one-half to two-thirds of the solids are precipitated. The precipitate formed gradually sinks to the bottom and carries down with it the greater part of the suspended matter, and the clarified fluid is run off and further treated or discharged into the sea or a river as the case may be. The process has little to recommend it, partly on account of the expense and difficulty attending the removal and safe disposal of the precipitate or "sludge" from the bottom of the settling tank, and partly because the effluent is by no means pure, but is still capable of putrefaction, and pathogenic organisms pass away with it unharmed—

Chemical treatment is now looked upon as out of date: it retards putrefaction but will not prevent it.

The biological processes may be considered under three headings—

(*a*) *Broad irrigation or sewage farming.*—The sewage is distributed over the surface of a chosen plot of land, which should be of a porous character, by a system of bunds and channels, the object in view being to obtain as abundant crops as possible consistently with due purification of the

sewage. The action that takes place is (1) mechanical filtration by the soil, (2) nitrification of the organic matter by the nitrifying organisms in the soil, (3) absorption of the resulting products by the roots of the plants grown. The sewage must pass through the soil and not merely over it. Much of the liquid is evaporated and the rest soaks into the soil. It may be necessary to under-drain the farm to carry away the excess of liquid. If the area of land available is large enough to deal with the quantity of sewage applied to it, the result is very good and can be allowed to join the sub-soil water or drained into a water course without danger or risk of putrefaction. If too much sewage be applied the ground becomes sodden, purification does not occur, and the crops will not flourish. The only danger is the possibility of unpurified sewage passing directly into the sub-soil through cracks, and contaminating wells in the neighbourhood or even at a considerable distance, but this is only likely to occur in a sub-soil of chalk or clay and not in sand.

The sub-soil drainage pipes should lead through an inspection chamber from which samples of the fluid can be taken to ascertain the degree of purification arrived at. One acre of land will deal with the sewage of 150 inhabitants in temperate climates, and in India where the evaporation is much greater, a smaller area is required.

Harriali grass is the crop grown on sewage farms in Madras, but sugarcanes, plantains, vegetables, and even fruit trees, can be cultivated with equal success and profit, if care and trouble be taken. No harm results from eating vegetables manured in this way.

(*b*) *Intermittent downward filtration* is only employed when suitable land for sewage farming is not available. The object is to purify as large a quantity of sewage on as small an area of land as

possible. Cultivation is carried on, but the produce is of secondary importance to the purification of the sewage. Porous beds of gravel and sand have to be laid down if the area is not of a sufficiently porous nature, and under-draining must be employed. The principle of the action is the same as in sewage farming. Some of the solid matter is first removed from the sewage by precipitation or sedimentation to prevent the pores of the filtering surface being blocked up, and the land is divided up into plots, each of which is irrigated, say for 6 hours, and allowed to rest and aerate itself for 18 hours, while another is being used. This is to allow the nitrifying organisms time to do their work of purification. The effluent is clear and does not putrefy and can be drained off into a river.

Another method is to divide the available area into seven plots and use one on each day of the week, allowing the others to rest and aerate meanwhile. One acre of prepared land will deal with the sewage of 1,000 inhabitants.

(*c*) *Biolysis* of sewage or solution by living organisms. Bacteria are divided into three groups—

(1) Those that require oxygen for their growth—aerobes.

(2) Those that cannot grow in the presence of oxygen—anaerobes.

(3) Those that will grow either in the presence or in the absence of oxygen.

All these groups contain bacteria which take a part in the purification of sewage: but in order to obtain the best results the sewage must be exposed to the action of the first two groups under the conditions most favourable to them. It is impossible here to attempt to describe the different arrangements that have been invented for the purpose of treating sewage by biolysis; the principles merely can be discussed.

It must be understood that a *water filter* acts as an interceptor of organisms and prevents their passage ; whereas a *sewage filter* provides a mesh work lined with bacteria, which live on the sewage which slowly trickles past them and extract the putrefiable organic matter from it. The three outstanding methods for treating sewage are :—

(1) The bacterial contact bed.
(2) The anaerobic system (septic tank).
(3) The continuously aerating filter.

These methods are generally employed in conjunction with each other to obtain the best results.

The contact bed is a water-tight tank 3 or 4 feet deep filled with broken clinker or stones, on the surface of which the purifying organisms grow. The sewage is first of all usually run through a grit chamber to allow mineral matter to subside and then collected in a septic tank, large enough to hold a 24 hours' flow. Air and light may be excluded by a roof, but this is not absolutely necessary, for a thick scum usually forms on the surface of the liquid which serves the same end. It takes 24 hours to pass through the tank, and all this time it is being acted on by anaerobic organisms which feed on and dissolve the solid organic matter and give off large quantities of inflammable gases in the process. On leaving the septic tank the sewage has been partially purified. To prepare it for the action of the aerobic organisms, it must be mechanically mixed with air and then run into the contact bed which should be filled in one hour. The sewage is allowed to remain in it for 2 hours, and then the bed is emptied in 1 hour and allowed to rest for 4 hours before it is again filled. Roughly speaking, a contact bed can be filled thrice daily, and one cubic foot of material will deal with one cubic foot of sewage in a day. The contents of the first bed are discharged into a second contact bed

containing a finer filling material and the same times are occupied in filling, emptying and resting. The effluent from the second contact bed is clear and odourless.

The aerobic organisms which collect on the rough surfaces of the filtering material complete the process of purification by feeding on the nitrogenous matter rendered soluble by the anaerobes in the septic tank, and by breaking it up into non-inflammable gases and simple salts.

The effluent or final product contains little or no organic matter, but a considerable quantity of mineral salts in solution, nitrates, chlorides, sulphates, phosphates, etc. By this means a non-putrescible effluent containing all the substances necessary for the support of vegetable life is obtained from the crude sewage, without the formation of immense quantities of sludge and without the expense of chemicals.

It can be run into a river directly, but it is far better to utilise it for irrigation, having regard to its high manurial value. It is not yet decided whether pathogenic micro-organisms ever appear in such an effluent or not, so it is as well to be on the safe side and to treat the effluent as if it might contaminate drinking water.*

In some modifications of this process no septic tank is used, but the sewage passes first through an upward filtration bed, in which it is acted on by the anaerobic organisms, and then through downward filtration beds which contain mainly aerobic organisms.

It is essential that the downward filtration beds should be allowed to rest empty several

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* The Sewage Commission sitting in England in 1902 held that this method cannot yet be relied on to remove pathogenic organisms. The effluent should therefore be further purified on land.

hours to aerate themselves thoroughly before being filled again.

Combined with previous treatment in a settling or septic tank, continuously aerating filters, such as Stoddart's, afford the best means hitherto devised of purifying sewage. These filters are built up on an impervious platform, and consist of stones or clinker not less than one inch in diameter, six or more feet in depth, with a loose, stone retaining-wall on each side. Each face of the filter is open to the air and the sewage is continously dripped on to the surface of the filter from the points of a patent distributor, which number 360 to the square yard. The sewage is thereby brought into constant and intimate contact with the air while it trickles through the interspaces of the material, and is acted on by the aerobic bacteria which find a resting place on the rough surface. This system claims to deal with 1,000 gallons of pure sewage over every square yard of filter surface in the 24 hours, whereas a contact bed can only deal with 200 gallons in the same time.

As well as being efficient, the Stoddart filter is simple, and, when once it has been properly fitted up, it works continuously with very little attention. Contact beds require a great deal of skilled attention. Stoddart's filter is eminently suited for dealing with the sewage of institutions and large private houses. The effluent can be used for irrigating a vegetable garden or grass farm.

Biolysis is the cheapest, most satisfactory and safest way of dealing with sewage when suitable land is not available for broad irrigation, and the method has a wide application. In India it is being used for the purification of sewage mixed with excreta, of the waste liquor and washings from dye works, of ordinary sewage, and in connection with

public latrines. It can be arranged to purify the sewage of a large town or of a single house standing by itself.

Inspection of Sewers.

Sanitary officials have generally little to say in the matter of the laying of sewers, but there are certain points to which they should not fail to direct attention.

These are firm foundations, proper gradients, correct size and shape, junctions in direction of flow, direct lines and wide curves, smooth surface, imperviousness of materials, free ventilation and facility of inspection at all points.

Sewers may leak for various reasons, such as sinking of foundations, fracture of joints, fracture of pipes by heavy traffic, imperfect jointing and laying (very frequent in India by reason of the carelessness of coolies and their supervisors), fracture of pipes during cleaning operations for the removal of silt, and penetration of roots of trees through faulty joints and cracks.

Leakages may be detected in several ways. The hydraulic test consists in blocking the lower end of the length of pipe line to be tested and filling it up with water. If the level of the water sinks, a leak is indicated. Less severe tests are to fill lengths of pipe with smoke or a strongly smelling liquid, and the eye or the nose may then be able to detect leaks if the pipes are exposed.

Public Latrines.

in towns are a necessity in poor districts in which the houses are too small each to be provided with such a convenience, and the occupiers too poor to pay for the services of a private scavenger. They

are also required in business parts of the town where large numbers of coolies are collected for work.

Many different forms of *public latrines* are in use which vary from a simple mud walled enclosure to a highly complex structure of iron and pottery. A mere enclosure has of course nothing to recommend it, but of the other patterns, no one can be said to be pre-eminently the best.

Far more depends on the innate ideas of decency of the persons who use the latrine than on the many devices introduced with the object of securing a particular position during the act of defæcation. However well thought out a latrine may be, it will be misused; therefore the simpler it is the better, and trouble expended in securing efficient scavengering is better repaid; in fact it is the only way nuisance can be avoided in a much frequented latrine.

All forms of latrines which are simply enclosures with either a sandy or cemented flooring on which the excreta are deposited, to be scraped up at leisure by the scavenger in attendance, are to be utterly condemned. The only permissible pattern in places where hand removal is practised is one which permits the excreta to be dropped directly into an iron receptacle which can be tightly covered and removed when full to the trenching ground, where it can be washed, disinfected and returned.

Collection in small buckets which are emptied behind the latrine into larger receptacles or carts and are then replaced unwashed, must give rise to nuisance.

In addition to fæcal matter there is the urine and ablution water to be accounted for. In a large public latrine it is practically useless to try to aim at the separation of fæces and urine, and, amongst vegetable eaters whose fæces are generally only

semi-solid, it is not a point of such practical importance as amongst meat eaters whose fæces are drier and more solid. Dry fæces, unmixed with urine or liquid, do not decompose and become offensive so quickly as wet fæces. It is usually the best plan, therefore, for the fæcal matter and urine to be collected in the same receptacle and for the ablution water to be conducted to a separate impervious covered cistern, whence it can be pumped into a tank cart and taken to the trenching ground.

In some places public latrines have been built over large impervious tanks into which the excreta drop directly through trapped openings. The tank acts as a septic tank and, under the influence of anaerobic organisms, the organic matter becomes liquified and the contents of the tank are more easily dealt with than fresh excreta.

In jails, hospitals, schools and institutions in which the people are under control, various patterns of latrines can be used successfully which are not practicable for the general public. Here the dry earth system and separation of solid and liquid excreta can be enforced, and the more complicated types of patent latrine seats find their chief use.

It is a good plan in such an institution to exclude flies entirely from the latrine by surrounding it with *wire gauze*, the exit and entrance being similarly guarded by double swing doors covered with gauze. The danger of the contamination of food and water in the institution by flies which have been feeding in the latrine is thus entirely done away with.

Where a sewerage system exists, all public latrines should be connected directly with a sewer, and the whole trouble, nuisance, danger and expense inseparably connected with hand-removal is at once avoided. The arrangement is simple, merely a *cemented trough*, $1\frac{1}{2}$–2 feet deep covered with

stone slabs with sufficient apertures between them. The fæces are removed from the trough at stated intervals by a flush from an automatic tipper, and pass through an intercepting trap into the sewer. The seats should be partitioned off and the latrine light and airy. Respectable people who would not go near an ordinary latrine use this type willingly, as it is always clean and there is no smell. Moreover, in Madras at least, trough latrines are not misused and fouled in the way in which other patterns usually are.

Public Urinals.

The provision of *urinals* in crowded public highways is part of the duty of the Municipal Council. When sewers are handy, and plenty of water for flushing, there is no difficulty in keeping them clean; but if the urine has to be collected in a tub it is almost impossible to avoid some nuisance. No filtration on the spot is generally successful, and the only remedy lies in frequent removal.

Private or House Latrines.

The patterns of *house latrines* are numerous, and cannot be described here: the essential points being a smooth and impervious flooring which can be readily cleaned, and some form of moveable receptacle to catch the excreta.

There is no excuse for nuisance arising from a private latrine. The whole arrangement is on such a small scale, that the occupier can very easily take care that it is kept clean and that decomposition does not occur. No house latrine which consists merely of a seat over a pit in the ground which is emptied at intervals of weeks or months when it becomes filled up should be allowed. Excreta should always be removed from houses at least once

in the 24 hours, and while the receptacle is retained on the premises it must be so guarded that flies cannot obtain access to it. A house latrine, whenever possible, should be outside the house itself, and as open to the air as circumstances allow. When a sewerage system exists, it is best that the house latrine should be connected up with the street sewer; all fæces, urine, ablution and other waste water can in this way be removed from the premises expeditiously. Several excellent patterns of seats specially designed for the use of natives of India are on the market, together with flush tanks for flushing out the receivers, and it is only a question of time for all the houses of the better class of inhabitants to be fitted with something of the kind.

It is just as well that these water-closets should be situated outside the house, for decomposition goes on quickly in India and sewer gas is more likely to be forced through the disconnecting traps than in temperate climates. Moreover evaporation is rapid, and the water seal of a trap in dry weather does not take long to disappear if the closet is unused for a few days, and so permit the free passage of sewer gas into the house.

Village Latrines.

The custom of the inhabitants of small villages to resort to the fields with their lotahs for ablution, is excellent in principle; but they should prefer cultivated fields instead of waste ground, in order to save valuable manure and utilise the deodorant properties of tilled soil, and it would be an improvement to imitate the practice of the ancient Jews who buried their ordure. The banks of tanks, streams and canals near villages, are almost invariably used as latrines, the water being convenient for ablution. Village authorities should be taught the danger of such pollution, its tendency to cause

the spread of intestinal worms, dysentery, cholera, and some other diseases; and they should be responsible for its prevention.

Latrines, however, cannot ordinarily be dispensed with, whether for public or for household use. In villages, decency, cleanliness, deodorisation and utility would all be promoted by a simple plan of moveable latrines; shallow trenches 9 inches wide and 9 inches deep being dug every afternoon and surrounded with a moveable wall of matting, the old trenches being filled in and the latrine moved to fresh ground every day, or less frequently according for requirements. Persons using these trenches should squat across them with a foot on each side. If villagers could once be induced to adopt this plan they would probably appreciate its advantages and willingly retain it. Small latrines of this kind may also be advantageously used in private gardens when these are sufficiently large.

The want of small towns and villages is not the provision of public latrines, so much as attention to the condition and cleansing of the private latrines which exist, or should exist, in connection with all houses. Sick people, children, gosha women, and all persons at night, must have some place on the premises where they can relieve the calls of nature. The pollution of soil and air which habitually goes on in the dwellings, is as dangerous to health as it is disgusting to the senses.*

The inhabitants of Indian villages have not yet grasped the importance of saving everything of manurial value, a principle which is realized to the

* Such foul places may be found attached to every house, not only to the houses of the poor. Kanny Lal Dey (Hindu Laws and Social Habits, Calcutta, 1866) gave graphic descriptions of the rarely cleaned ash pits, privies and cess-pools, with adjoining wells and dirty bathing pools in houses of the wealthier classes. Such descriptions are still too frequently applicable.

full by the Chinese and Japanese. The deposit of excreta on the surface of waste land in and around villages, is not only a dangerous practice but it is also a very wasteful one. On decomposition occurring, the greater part of the nitrogenous matter which should have been fixed in the soil is dissipated into the air as ammonia gas.

The Chinese carefully preserve all solid and liquid excreta and collect them in cemented pits in their fields and vegetable gardens. These pits really act as septic tanks, and solution of the solid matter goes on in them until the contents are sufficiently changed to enable them to be used for fertilising the crops. Fresh excreta cannot usefully be put to plants.

CHAPTER X.

DISPOSAL OF THE DEAD.

Customs and ceremonials which are associated with the disposal of the dead are too deeply established to be changed by sanitary legislation. All that can be hoped for is the gradual introduction of modifications in the direction of improvement, when the methods in vogue are opposed to sanitary ideals. The object to be aimed at is to dispose of the dead in such a way that no risk is run of interfering with the health of the living, having due regard to the sentiments of the relations and of the populace generally, and to the religious observances peculiar to each sect. The only two methods which demand consideration are earth burial and destruction by fire.

Earth Burial.

When a body is buried it is desirable that it should become disintegrated as quickly as possible, and that this should be accomplished without pollution of any water-supply or of the air in the neighbourhood. All local conditions which favour rapid disintegration are to be sought for, and all customs which favour it encouraged. All local conditions which hinder it are to be remedied as far as possible, and all unfavourable customs discouraged.

The principles which should govern the selection of a burial ground are:—

(1) That it should be as far as possible from the inhabited area. The distance cannot be very great for the sake of the convenience of the public, yet burial-grounds are meant to last for many years,

and probable extension of the town in that direction must be allowed for.

(2) Elevated ground should not be chosen, for the natural drainage of the burial ground might then find its way into water supplies or beneath houses at a lower level.

(3) The nature of the soil is important. The subsoil water should be at such a depth that it never rises to within 6 feet of the surface, otherwise the ground must be drained. The soil itself should be light and porous.

The management of all burial grounds must be carefully surpervised by the sanitary officials.

They should be surrounded by a wall or adequate fence and the whole area should be marked out into plots, and interments should made in regular lines allowing 2 feet between each grave. Burials here and there, wherever fancy strikes, should never be permitted, and accurate plans to scale should be kept of all burial grounds in which each interment with its date is entered, so that it may always be known how much fresh space is available, and when each particular spot was used. Pathways must be made at convenient intervals and trees should be planted. Six feet is the depth usually prescribed for graves, but it is certain that this is much too deep for rapid resolution of the body. Very shallow burial is not practicable in India, for jackals and dogs may dig up the corpses at night, but a depth of 3 or 4 feet would probably be sufficient to prevent this and would be better than six.

Tanks and wells in burial-grounds should not be allowed, as the water they contain is likely to be dangerous. Any water required for ceremonial purposes should be supplied by a pipe or brought in a tank-cart from without. Permission to open up old graves for the interment of other members of the family should be sparingly given. Many

of the burial-grounds in India have been in use for centuries, and the whole area has been covered so many times that it is impossible to dig anywhere without turning up bones. Such places should be closed for burial. Endeavours should also be made to get all burial-grounds in the neighbourhood of houses closed.

Burial in vaults and brick chambers should be discouraged. The European custom of using thick and heavy coffins is a bad one, for the disintegration of the bodies is much delayed thereby. Decomposition cannot be prevented, the body cannot be preserved, so it is futile to attempt to delay it. A far more rational proceeding is to enclose the body in a cloth, light wooden shell or wicker basket. Exposure of bodies—the Parsi custom—has certain objectionable features, but there is nothing but condemnation for the practice of throwing dead bodies into rivers or burying them in the river bed in the dry season.

Cremation.

Many nations which now practice earth burial are beginning to find difficulty in reserving sufficient space for the purpose, and this difficulty, together with a gradual realisation of the sanitary advantages of cremation, is leading to an extended use of crematoria.

The only valid objection to cremation, other than religious scruples, is the possibility that homicide might occasionally go undetected if bodies were habitually totally consumed by fire. Medical examination and analyses of exhumed corpses occasionally leads to the detection of crime.

Cremation properly carried out is sanitarily unobjectionable, but the crematorium should not be situated within 200 yards of any dwelling house. A properly constructed furnace consumes a body in

about 2 hours and leaves about 3 pounds of ashes. The fumes are passed through a furnace before being permitted to escape into the air so that all noxious gases are destroyed. The ashes may be disposed of in any way the relatives think fit. The more primitive method of cremation employed by Hindus is unobjectionable, provided that it is properly performed, and the corpse is entirely consumed. Burning grounds, however, are a source of nuisance when situated near habitations, on account of the smell emitted.

Dead bodies, especially those of persons who have died from infectious diseases, should not be kept long in houses, but should be cremated or buried as soon as possible. Those which are likely to spread infection or have become offensive should be completely wrapped up in a cloth saturated with some disinfectant before removal.

Animals which have died from old age or disease must never be used for food, and provision must be made in all towns for their proper disposal, just as much as for human remains. Animals which have died from non-infectious disease may be buried at the town refuse depot; but any dying from infectious disease should be cremated, and provision for this purpose should be made at each rubbish depot. Modern incinerators usually have a special cell designed for receiving and cremating carcases of large animals.

CHAPTER XI.

OFFENSIVE TRADES.

A number of trades have to be supervised by the Sanitary officials of towns, partly on account of the smells they give rise to being a nuisance to the neighbourhood, if not actually prejudicial to health, and partly on account of the materials or processes employed in the manufacture being sources of danger to the health or lives of the workmen.

The Sanitary Department must endeavour to control nuisances and to enforce improvement of the conditions under which the men labour. At the same time it has to be remembered that business must be carried on, and that affairs are not always prosperous enough to enable the changes to be carried out that are desirable from a sanitary point of view.

Besides truly offensive trades, there are numerous industries connected with food-supply which have to be licensed and kept under supervision for the safety of the public health.

Ballard * has classified offensive trades as follows :—

(1) The keeping of animals.
(2) The slaughtering of animals.
(3) Industries which deal with matter of animal origin, *e.g.*, tanning, bone-boiling.
(4) Industries which deal with matter of vegetable origin, *e.g.*, oil-mills, distilleries.

* Report to Local Government Board of England.

(5) Industries which deal with mineral matter, *e.g.*, chemical works.
(6) Industries which deal with animal, vegetable and mineral matter.

The supervision of offensive trades has not yet assumed the importance in India that is attached to it in Europe, but the number of factories is rapidly increasing, and legislation is proceeding in connection with them. In order to be able to suggest to owners of factories, whether conducted on a large or a small scale, how improvements in the conditions under which their operatives labour may be made, and how nuisances may be avoided, the Sanitary official must possess an intimate working knowledge of the processes of the manufacture. Suggestions which would hamper the labourers, diminish the output, cause a decline in the quality of the goods, or involve the expenditure of such a sum of money that the business would cease to profit, cannot be entertained. As in sanitary matters generally, the ideal is often unattainable for want of funds, and it is far better to do the best that can be done under the circumstances, than to suggest or try to enforce the impossible, and to effect nothing in the end.

The sanitary regulation of large factories will, in future, be in the hands of special factory inspectors, and their internal arrangements do not therefore concern the town Sanitary officer, except in so far as the effluvia emitted may be a nuisance to the neighbourhood. The Sanitary officer may, however, be called upon in connection with the removal and disposal of waste liquors, sewage and refuse generally from factories, and these must be dealt with in accordance with the principles detailed in preceding chapters. It is the minor industries which are carried on on a small scale that need attention, for these are outside the range of the factory inspectors. All industries require an annual license from the health department of the town, and must be

frequently inspected to see that the terms of the license are being adhered to. The main points to be looked to in deciding whether these places are fit to be licensed are, as regards the Madras Presidency, detailed in a memorandum issued by the Sanitary Commissioner.

Some of the minor offensive trades which are carried on in the Madras Presidency are enumerated below:—

Oil boiling.
Oil-mills.
Camphor boiling.
Bone boiling.
Paddy boiling.
Indigo dyeing.
Bone depots.
Salt fish depots.
Tanneries.
Skin godowns.
Arrack distilleries.
Paper factories.
Slaughter-houses.
Public cattle-yards.
Hack stables.
Pig keeping.
Chemical works.
Soap boiling.

Working with poisonous metals.

Any manufacture in which noxious gases and smells are evolved or foul liquors are discharged.

Industries which are not offensive trades, but for the public safety must be licensed and kept under observation by the Sanitary authorities:—

Private markets.
Private cattle-yards.
Bakeries.
Sweet-meat bazaars.
Aerated water factories.
Ice factories.
Cart stands.
Meat stalls.
Dhobi houses.
Dhobi washing places.
Hotels.
Eating houses.

CHAPTER XII.

COMMUNICABLE DISEASES.

Communicable diseases are those which are due to the growth, in or on the human or animal body, of parasites either animal or vegetable in nature. These parasites can be transferred from host to host either directly or indirectly, and, under favourable conditions, give rise to the train of symptoms peculiar to each species.

Parasitic organisms which can thus cause disease are styled pathogenic. Some are strict parasites, that is, they can only exist in the body, not in the external world, *e.g.*, the tubercle bacillus and the gonococcus. They are conveyed from person to person directly, or nearly so, through the medium of discharges, shed skin, dust or insects.

Others are partly saprophytic, that is, they can exist and reproduce themselves for weeks at a time outside the body, *e.g.*, the typhoid bacillus.

Some are peculiar to the human species, some to certain animals, and some are common to both man and animals.

The lowly organised vegetable parasites can be transferred directly from host to host, but the more highly organised animal parasites often have a complex course of development, and part of their existence has to be passed in the body of some intermediary host, such as an insect.

Classification—

Micro-parasites of vegetable nature.	*Bacteria.* *Yeasts* *Moulds.*
Micro-parasites of animal nature ...	*Protozoa.*
Larger animal parasites	*Metazoa.*

METAZOA.

Parasites which are found in the alimentary canal are termed entozoa, and those which live on the surface of the body ectozoa.

Trematodes or flukes.—*Fasciola hepatica*, about ¾ inch long: is found in the gall bladder and ducts of sheep and numerous other herbivora and occasionally in man. It is sometimes the cause of severe epidemics and death amongst sheep in Burma, but a large proportion of the sheep killed in the Madras slaughter-houses harbour a few without much apparent harm. The ova, evacuated with the fæces, hatch in any tiny collection of water, and the embryo finds its way into a small mollusc and finally becomes encysted, and is taken into a fresh host with grass or water plants. Extensive areas of pasture land may be infested by this parasite.

Other species of flukes, of which the life history is not accurately known, are found in the intestines and lungs and sometimes the brain of man.

Bilharzia hæmatobia is a trematode which is common in Africa and has recently been transported to India. The worm inhabits the portal vein and its tributaries in the bladder and rectum, and is the cause of severe hæmaturia. The ova pass out with the urine and fæces, and the embryo develops in a minute crustacean in water, and so enters the human stomach with water that is drunk.

Cestodes or tape worms in their mature form inhabit the intestine of man and most animals. The eggs of the worm are evacuated with the fæces in enormous numbers, and some of them are taken into the alimentary canal of other animals with the food. There they hatch, and the embryo worms work their way into the muscles of the animal where they

become encysted and form small bladder-like bodies about the size of a grain of boiled rice. If the flesh of the infested animal is eaten in a raw or imperfectly cooked state, these bladder-worms complete their development in the intestine of the new host and become the full grown tape worm.

Tænia Saginata.—The fully developed worm inhabits the small intestine of man. The embryo is found in the muscles of cattle. Only beef-eaters, Mahomedans and Christians can, therefore, become hosts of this worm.

Tænia solium in its fully developed form inhabits the intestine of man. The embryo finds its intermediate host in the pig, so only pig-eaters can harbour this parasite.

The flesh of animals which harbour the embryo forms of these worms is termed "measly." Several other tape worms are occasionally found in man, and man is occasionally the intermediate host, having the bladder-worm stage in his muscles.

Tænia Echinococcus is a tape worm which inhabits the intestines of certain carnivora, dog, jackal, etc. The eggs find their way into the intestines of pigs, cattle and man in polluted food and water, and the embryo develops in their body, particularly the liver, giving rise to the dangerous condition known as hydatid cyst. Echinococcus hydatid cysts are frequently removed from animals' livers and flung about in slaughter-houses: hence dogs should be sedulously excluded, for in them the further development of the worm can proceed, and by them human beings are generally infected.*

Nematodes or round worms vary very greatly in size and in their life history.

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* Sometimes as much as 14 per cent. of horned cattle slaughtered at Rawal Pindi are affected with cystic disease.—*Report of Indian Cattle Plague Commission* 1871.

Ascaris lumbricoides, the common round worm, is exceedingly prevalent in the small intestine of man in India. The eggs leave the body with the fæces and are taken in again with polluted food and water, either by the same or another individual. No intermediate host is required for the development of this worm. Over 2,000 of these worms were removed from the intestine of a child in the Madras General Hospital a few years ago !

Oxyuris Vermicularis, the common thread worm, inhabits the large intestine of man. The eggs are passed out with the fæces and gain entrance to fresh individuals by polluted food and water.

Anchylostoma duodenale is the cause of the disease called anchylostomiasis which has assumed, during recent years, a most important position, not so much on account of the mortality directly due to it, as on account of the physical disability of persons harbouring the worms. Though not confined to the tropics, the disease is in great measure dependent on temperature ; and the extra-corporeal existence of the worm, which is endangered by cold, can be maintained without injury in deep mines, for the temperature is always fairly high deep below ground. If the disease is widely spread in a large industrial community, such as amongst the coolies in a tea plantation, the miners in a mining district, or the labourers on great engineering enterprises, the work cannot progress, and the financial loss to all concerned may be great. Hence the necessity for accurate knowledge of the life history of the worm, so that suitable preventive measures may be taken.

The symptoms caused by the worms are those of a progressive anæmia, and the degree of ill-health corresponds in some measure with the number of worms harboured. Whether the anæmia is caused by the direct abstraction of blood, or by

the injection into the host of some toxin, is not yet clear.

The adult worm inhabits chiefly the duodenum, its ova leave the body of the host with the fæces, and under the influence of warmth and moisture embryo worms hatch out.

The life of the adult worm in the duodenum may extend to five or six years, and the length of time an embryo can survive outside the body and under favourable conditions, is certainly not less than a year. Neither ova nor embryos are destroyed by the freezing of the mud or water in which they may be lying.

Ova and embryos may be transferred from infected soil to the food by unwashen hands, thus fresh individuals become infected.

Embryos can also penetrate the unbroken skin of a man and infect him by this channel. Whether a man becomes infected by the mouth or through the skin, it takes from 30—35 days for ova to appear in his fæces.

The irritation of the skin due to the passage of embryos is the cause of various forms of itching skin eruptions, generally of the legs.

For the prevention of the disease, the strictest precautions must be taken with regard to the disposal of excreta amongst labouring communities to avoid pollution of the soil and water. A single cooly harbouring a few of the adult worms, even though in good health himself, may be the starting point for the spread of the disease amongst all the rest.

On account of the vitality of the embryos outside the body, a mine or tea garden once infected is very difficult to deal with, and numerous substances have been tried to destroy the embryos in the moist soil. The best agents appear to be solutions of ferrous sulphate 1 per cent., sea salt and creasote.

To prevent skin infection whilst working in soil containing the embryos, great care must be taken of the hands and other parts of the body likely to become soiled. Boots to be of any use must be high, for the active embryos can travel over them when wet, and they must be disinfected daily. Another method, which has been tried amongst coolies who will not wear boots, is to make each one, before going to work, step into a vessel containing tar, so that his legs get a coating of it up to the knees.

At the same time the internal treatment of infected individuals must not be forgotten in order to destroy the adult worms in the intestine.

It is not yet absolutely certain whether each species of animal harbours its own particular species of anchylostoma, or whether dog anchylostoma can be transferred to man and *vice versâ*.

Filaria medinensis or guinea worm is a nematode worm, the female of which is found beneath the skin of man. It bores through the skin, generally of the leg, and discharges its embryos into water where they continue their development in a fresh water crustacean, and are reconveyed into the body of man with drinking water. Improvement of water-supply brings about a disappearance of this parasite. Thirty-five years ago it used to be fairly common in Madras City, but during the past ten years not a single case has come to notice which had its origin in the city: the few cases which seek admission to the hospitals have been infected elsewhere, *e.g.*, Bellary and Cuddapah districts.

Filaria sanguinis hominis or blood worm.—Embryos of this worm are found in the blood of persons affected with elephantiasis, lymph scrotum, and chyluria ; and in districts where this disease is prevalent embryos are found in the blood of a

considerable percentage of otherwise healthy persons. The adult worms live in the lymphatic vessels. The female, a hair-like worm 3 inches long is viviparous, and may live for years in a man without causing inconvenience to her host, so long as she discharges only developed embryo-worms which pass through the lymph glands into his blood. Manson's theory is that she occasionally aborts and discharges ova instead of embryos into the lymph stream. These, being too large to pass the lymph glands, stick fast and cause obstruction; the condition known as elephantiasis follows. When mosquitoes feed on a person whose blood contains embryos, they suck out some of these with the blood. In certain species of mosquitoes the embryos are able to undergo further development. Manson's original idea was that the mosquitoes containing the embryos flew to water to lay their eggs and died there, and that the embryos set free in the water found their way again into human beings when the water was used for drinking. Later observations have shown that the embryos find their way into the proboscis of the affected mosquito, and it is therefore possible that they may obtain entrance into the human body while the mosquito is in the act of biting. Whatever its exact method of spreading, the fact remains that the disease is a very local one: even in towns some quarters are badly affected, while others are free. Improved drainage and water-supply tend gradually to eradicate it.

A peculiar point about elephantiasis is that it does not originate far from the sea coast; the disease, unless imported, does not exist in inland districts.

Several other nematodes are found in the intestines and tissues of man and other animals.

From what has been said about the life history of the foregoing parasitic worms, it will be evident

that the usual method of entrance into the human body is with the food and drink, and that scrupulous care in the cooking and cleanliness of food and in obtaining a pure water for drinking will be sufficient to protect anyone from being troubled with them.

Occasional parasites of man are lice, bugs, fleas, ticks, leeches, and a variety of winged insects, including mosquitoes. A detailed description of all these orders and species is not possible here, and their interest to the sanitary official lies mainly in the fact that various bacterial and protozoal diseases can be conveyed to man through their agency, either directly, *i.e.*, mechanically, or indirectly, after a period of development passed in an intermediate host. The more important instances of transmission of disease by insects will be mentioned in dealing with special diseases and their prevention. The moral to be drawn at the moment is that every biting insect is a potential carrier of disease, not only to man but also to animals, and so efforts should be made to destroy them whenever possible, and to take precautions to avoid being bitten.

PROTOZOA.

These are all minute organisms which, compared with bacteria, have a complicated life history, and they nearly all pass a period of their existence in some suctorial insect. Some, however, such as the trypanosome of the dourine of horses and the spirochaete of syphilis, seem to be transmitted by direct contact. It will suffice here merely to mention the chief divisions of the class and the diseases with which they are associated.

Amœba.—Dysentery and liver abscess. Transmitted probably with polluted food and water.

Intestinal flagellates are found in the intestine. They are associated with no definite disease, but may

be the causative agents of some forms of diarrhœa. Transmitted with polluted food and water.

Trypanosomes.—Nearly all animals seem liable to trypanosome infection, but all species of the parasite do not seem to be pathogenic. Pathogenic species cause surra in horses and camels, transmitted by a biting fly, the tsetse fly disease of mammals in Africa, and the sleeping sickness of man in Africa.

Spirochaetes cause relapsing fever in man, tick fever, syphilis and yaws.

Leishmania.—Kala-azar and oriental sore.

Coccidia occasionally affect the liver and intestines of man.

Hæmosporidia.—Malaria in man and apes; piroplasma in cattle, horses, sheep and dogs.

Sarcosporidia cause a disease of the muscles which is rare in man, but common in sheep, pigs, and cattle, especially buffaloes in Madras.

Unclassified organisms.—Small-pox, rabies, trachoma, the distemper of dogs and a disease of fowls.

The prevention of diseased conditions due to parasitic protozoa obviously demands an intimate knowledge of the life history of each parasite, for until it is known exactly how each parasite is conveyed to its human host, all preventive measures undertaken must be steps in the dark. Some of the more important of these diseases will be referred to again later.

Vegetable Micro-parasites.

Certain *yeasts* are pathogenic to man and birds, *e.g.*, the yeast of thrush. Certain *moulds* are the cause of various skin diseases in man, and *streptothrix* fungi cause the disease called *actinomycosis* in man and cattle and *mycetoma* or Madura foot in man.

Bacteria.—The vast majority of disease-microbes hitherto discovered belong to an order of extremely minute organisms of apparently simple structure, termed *Bacteria* or *Schizomycetes* (fission-fungi), the latter name indicating that they multiply by division, each half becoming a separate organism. Some species may multiply in this way with extraordinary rapidity. Bacteria have been classed according to shape,* into (1) spherical or ovoid bacteria (*micrococci*); (2) short rods (*microbacteria*); (3) long rods (*bacilli*); and (4) spiral rods (*spirilla*). Many bacteria are motionless, but some are motile and exhibit very lively movements caused by rapid lashing of one or more extremely fine whip-like processes (flagella). Bacteria comprise a large variety of species and are widely diffused in nature, being found almost everywhere in more or less abundance. Some species resemble each other so closely in appearance and size that it is impossible by microscopic examination alone to distinguish them from one another. If we can imagine large plants to be reduced to the minute size of bacteria, it would be equally difficult to distinguish many which we know are specifically distinct.

The conditions necessary for the growth of bacteria are (1) nitrogenous material suitable for their nourishment, (2) moisture, and (3) a certain temperature. Some require the presence of air, *i.e.*, oxygen, but others will only grow in a medium from which oxygen is excluded: others again can adapt themselves either to the absence or presence of oxygen. Different species of bacteria grow with different facility in various substances. Dead organic materials are their favourite soil, and the growth of microbes is the cause of decay and putre-

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* By Cohn.

faction ; but, as we see in disease-producing species, some may grow in the living tissues of animals or plants, especially when such tissues are deficient in their inherent vitality. Bacteria grow best in an alkaline medium, and moulds in an acid medium. As a rule, therefore, bacteria are the parasites of the animal kingdom since the tissues and fluids of animal bodies are alkaline, and moulds are the parasites of the vegetable kingdom since the juices of plants are acid.

Spores.—Most species of bacteria are capable, under some circumstances, of forming seeds or spores—extremely minute bodies—which retain their vitality for an indefinite time, even when exposed to some conditions (such as drying or exposure to a temperature below that of boiling water), which would kill mature bacteria. Spores in favourable surroundings bud out into bacteria.

Innocent and pathogenic bacteria.—To prove beyond all doubt that a certain disease is caused by a certain microbe, the following conditions * must be satisfied: (1) the microbes must be found in the blood or diseased tissues in all cases of the disease ; (2) the microbes must be isolated and artificially cultivated for several generations outside the body ; (3) on introduction of the microbes so cultivated into the body of a susceptible animal, the same disease must be produced ; (4) the microbes must be found in the blood or diseased tissues of the animal so inoculated.

All these conditions have been complied with in the case of several diseases of men and animals ; but such complete experimental proof is rarely possible, because, in some cases, of failure to cultivate the organisms outside the body, and, in other cases, of the impossibility of finding animals which

* Usually known as Koch's postulates.

are susceptible to the particular disease, and experiments of this kind cannot be performed on men.*

It is generally considered that if a certain microbe be constantly found in the blood or diseased tissues in cases of a given disease and not otherwise, the evidence that that microbe is the cause of that disease is all but conclusive, especially if the disease be proved to be communicable.

The term "pathogenic" (disease-producing) is generally restricted to those microbes which produce specific forms of disease when they grow within the body. Many of these microbes are very selective and exclusive as to the soil in which they will grow; they often require very complex organic substances for their nutrition, and restrict themselves to particular genera or even to single species of animals and sometimes to certain tissues only. Hence it is often difficult to cultivate some of them outside the living body. Their most important character is the power which they possess of growing in the tissues of healthy animals and producing, it may be, dangerous or deadly diseases in their hosts.

It is probable that many, if not all, pathogenic microbes may, under favourable conditions, grow outside the body. The anthrax bacillus is known to grow readily thus in damp soil or on decaying organic substances. Koch found his cholera bacillus in the water of a foul tank at Calcutta, and the enteric bacillus has frequently been found in contaminated water which had given rise to enteric fever, but as yet our knowledge is very scanty regarding the life history of disease-microbes growing outside the body. The geographical localization (endemicity)

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* It has often been proposed, but rarely permitted by any Government, that such experiments should be allowed on condemned criminals. There is nothing inhuman or improper in such a proposal. Men who had grievously injured their fellow beings would most fitly expiate their crimes by rendering such services to all humanity.

and seasonal prevalence of microbic diseases, that is, their being so much influenced by external conditions, are facts which somewhat favour the view that their specific microbes grow apart from as well as within the body.

Innocent or non-pathogenic microbes are found in immense variety and numbers in all decomposing organic substances; and different species often succeed each other in crops at various stages of decomposition, as the particular kind of nourishing material which each prefers becomes exhausted. Organisms of this kind are always found in the nose, mouth and intestines of animals, without producing injurious effects. If introduced into the healthy tissues or blood of living animals, they are speedily destroyed.

Ordinarily innocent microbes may, however, produce disease (though not specific communicable disease) in three ways: (1) they may produce poisonous alkaloids or extractives in decomposing articles of food; (2) they may cause decomposition of ingested food in the alimentary canal with local irritation and perhaps absorption of poisonous products; (3) they may grow in the discharges of wounds or ulcers, in abscesses, and in dead or dying portions of tissue, the decomposition products produced by them causing local irritation or general poisoning.

CHAPTER XIII.

INFECTION AND IMMUNITY.

In order that infection may occur, it is necessary for the parasite to enter into the body, that is to say, to penetrate beneath the surface. In this case the surface must be understood to include not only the visible skin but the lining of all the cavities which open on to the exterior of the body, such as the alimentary canal in its whole length. Micro-organisms on the surface of the body cannot be said to infect that body, but, as stated at the end of the last chapter, they may do harm and cause symptoms of illness by means of the poisonous fluid substances they can produce, which may be absorbed by the surface cells of the body. Infection can take place in two ways, (1) by an alteration occurring in the quality or quantity of the discharges and secretions of the surface cells, which may allow micro-organisms on the surface to multiply and to destroy the cells with which they are in contact, by the toxins or poisons they produce: the protecting layer being no longer intact, the micro-organisms can invade and grow inside the body; (2) by an accidental injury to the protective layer which permits micro-organisms to enter the body directly.

Infection or invasion of the body by micro-organisms, does not occur every time opportunity offers, partly on account of the natural protective power of the cells of the body, and partly on account of the variations in virulence of micro-organisms. The susceptibility of the tissues also varies greatly from time to time.

Infection is determined by the number of bacteria present at one spot at one time; the necessary condition to produce infection being the ability to overpower the resisting mechanism of the tissues, and this may be achieved as surely by a large number of bacteria of low virulence as by a small number of highly virulent ones.

The virulence of a microbe depends on the intensity of the poison it produces and on the amount of it formed in a given time.

The *toxins* or poisonous products of the growth of bacteria are of three kinds:—

(1) The substances directly excreted are poisonous in themselves;

(2) the substances excreted are not themselves poisonous, but they act on proteids in the tissues, and convert them into poisons;

(3) the poisonous substances are not excreted but are set free only when the bacteria are broken up.

Bacteria can, therefore, disturb the functions of the body in two ways:—

(1) through the absorption of their excreted toxins or by the changes wrought on the proteids by these toxins (simple intoxication, as in cholera),

(2) by their growth and the production of toxins within the body (infection, as in typhoid).

Antitoxins are substances elaborated by the cells of the body which neutralise the toxic products of bacteria, and so protect the body. An antitoxin can be artificially prepared by injecting increasing doses of a bacterial toxin into an animal, whereby its tissues are stimulated to produce large quantities of antitoxin. The blood of such an animal contains the antitoxin, and its serum can be successfully employed in the treatment of human disease, *e.g.*, diphtheria.

In bacterial as in most other orders of disease, infection of the body is to a great extent governed by factors which are beyond the power of the individual to control, but not beyond the power of the state to counteract in the course of time by research, education and appropriate legislation. The factors which predispose to disease are summarised in the following table :—

A.—Inherited.

(1) Characterising the species :—
 Man (*typhoid*).
 Cattle (*rinderpest*).

(2) Characterising the race :—
 Jews (*diabetes*).

(3) Characterising the family :—
 Tuberculosis.
 Gout.
 Neuroses.

(4) Characterising the individual :—
 (*a*) Sex (female disease).
 (*b*) Age (diseases peculiar to infancy, old age).
 (*c*) Tissue susceptibility.

B.—Acquired.

(1) Social status and environment.
(2) Injury.
(3) Malnutrition.
(4) Previous attacks.
(5) Exhaustion.

The normal defences of the body against infection are numerous and depend partly on the structure and integrity of the surface, partly on the vital energy, and partly on a complex of internal

conditions of which some are normal, though variable, and others are called into existence only by the stimulus of the infective agent :—

(1) The surface discharges (saliva, mucus, gastric juice, etc.) have physical or chemical properties which inhibit or destroy bacteria.

(2) The cells of the body, some in a higher degree than others, possess the power of phagocytosis, that is, they can enclose and digest or otherwise destroy bacteria which come into contact with them.

(3) The circulatory fluids of the body possess a certain degree of bactericidal power.

Modes of Infection.

Micro-organisms find entrance to the body (1) by inoculation through a wound of the skin or mucous membrane, though sometimes application to an unbroken mucous membrane is sufficient, (2) by inhalation into the air passages, (3) by the mouth with water or food. Sometimes a microbe can enter by one of these ways only, sometimes by all, but, having entered, symptoms of disease do not begin at once; there is a period of *incubation* during which the microbe multiplies enormously and spreads. Then the symptoms of the disease declare themselves, last a certain time, and finally the sufferer dies or recovers. In the body the microbes act by producing local irritation or destruction of tissues or blocking of vessels, or by producing substances which act as chemical poisons on the tissues of the patients. Recovery shows that the susceptibility of the person for the time being has disappeared, and is due to the formation of substances by the microbe in the body, which prevent its further growth, or to the powers of defence of the body being able to destroy the microbes and neutralise their poisons After recovery from such an attack, it is often the case, but not always, that the individual is insusceptible

to another invasion by the same microbe for a longer or shorter period, perhaps for life.

Several of these diseases, such as tuberculosis, anthrax, rabies, are common to man and lower animals and may be transmitted from one to the other.

The most important common characters of microbic diseases are the following:—each of these diseases is due to a specific micro-organism, and therefore each case of such disease can only be originated, directly or mediately, from a previous case of the same disease; the organisms which cause these diseases are capable of indefinite multiplication under favourable circumstances, within the body or external to it, and often are multiplied to an enormous extent in the bodies of affected individuals; many microbes show a preference for particular organs or tissues and for particular individuals or races (in the same way that larger plants show preferences for particular soils); there is a period of latency or incubation between the time of reception of disease-producing microbes in the body and the first symptoms of disease (being the period required for germination and multiplication of the organisms); many microbic diseases run a definite and limited course and, in such cases, one attack usually protects against further attacks of the same disease.

The analogy of microbes with larger plants is obvious. Seeds sown in fertile soil remain latent for a definite period, but eventually give birth to a crop of plants which run a certain course of life and multiply the original seed many fold. Each plant can only be propagated from the specific seed of a similar plant: rice seeds will only produce rice-plants, and small-pox seeds will only produce small-pox.

Plants of the same specific nature may, however, exhibit differences of vigour and variations, depending

upon differences of soil, season, or other conditions. Differences of activity and character in the same disease in different climates or among different races, or in different epidemics, may be similarly explained—indeed by artificial cultivation under certain conditions, or by growth in certain species of animals, some known disease-germs may be modified so as to have their virulence increased or diminished.

Modifications of breed occur very much more rapidly in microbes than in large plants, because the former go through very many generations in the time occupied by one of the latter.

The infective agent.—Diseases which are capable of transmission from man to man, whether immediately by direct contact or mediately through the air, by infected clothes, or by water or food, must be due to the passage of infective material from person to person. The actual infective matter is known by the term contagium. *Contagion* denotes the process by which the contagium is conveyed from person to person. The distinction between the once widely used terms *infectious* and *contagious* has been lost, and their use is therefore better avoided, those diseases which are due to a contagium being classed together as *communicable diseases*. In every case the contagium is a specific living organism, capable under favourable conditions of multiplying itself enormously. Sometimes disease is caused by the multiplication of the organism at the point of its entrance into the body, and the elaboration of powerful poisons or toxins, which are absorbed and give rise to the symptoms of the disease, *e.g.*, tetanus in man; sometimes the organisms produce only feeble toxins, but themselves rapidly invade the whole body, *e.g.*, anthrax in horses. The specific contagia (microbes) leave the body by various channels. In those

communicable diseases which are characterised by a skin eruption, the contagium is present in the dry scales which leave the surface of the body. Particles of this matter float about in the air and convey the infection, *e.g.*, measles and small-pox.

In other cases bacilli are found in the matter coughed up from the lungs, as in phthisis and pneumonia. In diseases affecting principally the intestines, the specific organisms are found in the fæces and urine, as in cholera and enteric fever. After leaving the infected person the microbes may at once obtain entrance into a healthy one, more frequently they have to survive for varying periods outside the body before re-introduction.

Ordinarily, contagia do not survive long in the air. Dryness, want of nourishment, light and oxygen all combine to destroy them, and diseases can only be propagated through the air for limited distances. It must be remembered too that the contagium is particulate matter, though very minute, and gradually settles down owing to gravity.

Organisms which are capable of forming spores stand a much better chance of survival in unsuitable media than those which do not, since the spores will resist desiccation and heat to a far greater degree than the organism itself. Many of the pathogenic bacteria are not known to spore.

In water pathogenic microbes may survive and even multiply freely under certain conditions, and similarly in the soil. Owing to the difficulty in isolating any species of bacillus when mixed up with thousands of others in water and earth, it is not yet possible to say how long pathogenic organisms will survive under different circumstances in earth and water, but at times the limit may certainly be measured in months. Again it is not yet clear whether soil and water are to be looked

upon as the natural resting place of certain of the contagia, from which they from time to time arise and invade men and animals, or not.

It must not be forgotten that contagion is possible through the medium of both domestic animals and men, who are not themselves affected by the disease.

The part played by *flies* and other insects as passive agents in the spread of disease can by no means be overlooked; some insects, such as mosquitoes and ticks, sometimes take an active part by acting as the intermediate hosts of the parasite.*

It is certain that flies may carry contagion. In the famine-camps in 1877, ophthalmia was so disseminated by them that hardly a child escaped. It is probable that they often propagate small-pox.

Acute communicable diseases, such as small-pox or dengue, are easily propagated, and the infective agent rapidly causes the typical diseased state. Groups of individuals are therefore affected, each case acting as a focus round which other cases occur. Such diseases are commonly epidemic and their communicable character is evident to all. Chronic communicable diseases, on the other hand,

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* All flies pass through the following stages of development :—

(1) Ovum or egg.
(2) Larva.
(3) Pupa.
(4) Imago or fully developed fly.

The common fly lays about 120 eggs in some mass of decaying organic matter. These hatch in about 8 hours and the larval stage lasts about 3 days during which the larvæ feed greedily and grow rapidly. They then change into pupæ, this being a resting stage lasting 4 or 5 days during which no food is consumed. Finally the adult fly emerges from the pupa. The whole cycle is thus completed in less than 10 days, so that in a month a single female can produce over a million descendants. It should be noted that flies cannot multiply in the absence of organic matter on which their larvæ can feed. A plague of flies, therefore, points to faulty sanitation and imperfect disposal of refuse, and is likely to be speedily followed by epidemic disease, to the spread of which the flies contribute by carrying about infective matter on their feet.

such as tubercle or leprosy, are not so easily propagated, and the symptoms develop very slowly in the newly infected person, so that the cases appear to have less connection one with another and their communicable character is not so obvious.

The *dose* of a contagium would theoretically appear to be a matter of little importance, since even one single microbe may multiply indefinitely. Practically, however, it has been found in some cases, that a small dose inoculated produces only a local affection, a larger dose being required to produce the general disease. A large dose of weak or attenuated virus is also required to produce the same effect as a small dose of strong virus. The weaker effect of a small than of a large dose may be due to the slower multiplication of the microbes, the parent microbes being fewer, and perhaps to some enfeeblement of the brood, in its struggle to obtain a footing in the body. If a community has been free from any communicable disease for a prolonged period, and that disease is again introduced, it affects the people much more severely than it was wont to do in former days, both in point of numbers attacked and in mortality. It seems therefore that immunity tends to disappear. If a disease is more or less continuously prevalent there must always be a considerable proportion of the population protected, and severe outbreaks consequently are not so likely to occur.

Susceptibility and Immunity.

Seed will not grow unless it be sown in suitable soil. It is a matter of common observation that large plants show preferences for particular kinds of soil and particular climates. Microbes show similar preferences, but many of them, especially pathogenic species, are more exclusively selective than large plants in this respect. Thus some

disease-microbes confine their attacks to one species of animal, for instance those of leprosy and cholera attack man only; while others, such as those of anthrax, not only attack animals of different species, but are known to grow very readily outside the body. The electiveness of microbes for particular soils is shown by the preference which some of them show, not only for a particular species of animal, but for a particular race or variety of one species and for particular individuals.

Susceptibility and immunity are relative terms and the one state is the converse of the other. Immunity is that condition of the body which renders it able to ward off the attacks of pathogenic microbes successfully, and to neutralise their toxins.

Natural immunity is a property of the body concerned, and cannot be removed from it with its blood. Probably all men possess certain degrees of resistance against all micro-organisms, which vary from time to time, and probably no man is completely resistant or immune against any pathogenic micro-organism, provided that the dose is sufficient. A susceptible person, or one of low resistance, will be infected by a small number of pathogenic organisms, whereas a less susceptible person or one of greater resistance would not be infected by a similar number. Hence, in times of epidemics, of a number of persons who have been equally exposed to infection, some will take the disease, others will not; and, of those who take it, some will have a severe or even fatal attack, others a mild one.

Acquired immunity may be active or passive. When an animal is injected with the toxic products of a bacillus, its tissues form an antitoxin, and when an animal is infected with dead cultures of a bacillus, its tissues form a substance which

is capable of destroying that bacillus. Both the antitoxin and the bactericidal substance are present in the blood of the animal, and can be collected for use by obtaining the animal's serum. The antitoxic substance has, however, no bactericidal power, and the bactericidal substance has no antitoxic power. Serums containing one or both of these substances can, in appropriate cases, be injected into other animals or men, and will confer on them a state of *passive immunity* which does not last very long, but may be sufficient to enable the infected individual to react against the toxin with which he is being poisoned or the bacillus which is multiplying in his tissues, as the case may be, and to recover from a disease which might otherwise have been fatal.

Passive immunity may assist in the cure of a disease already existing, but does not endure long enough to be of value as a prophylactic measure.

Active immunity, on the other hand, is a state which one strives to procure in the individual himself: it cannot be transferred in the medium of a serum. Active immunity may be generated against toxins by injections of toxins in gradually increasing non-fatal doses, which stimulate the tissues to form their own antitoxins, and against bacilli by injections of dead or attenuated or living bacilli in non-fatal doses, which provoke the tissues to manufacture bactericidal substances. This kind of action once started either proceeds of its own accord for a lengthened period, or is resumed in time of need on excitation by a fresh dose of toxin or bacilli. Immunity thus acquired lasts a sufficiently long time to be of the utmost value in protecting persons in epidemic times, though it gradually wears away. A state of active immunity of considerable duration is generally produced also when an individual has passed through an attack of an infectious disease and recovered.

Endemics and Epidemics.

A disease which occurs at intervals in isolated cases is said to be *sporadic ;* when it is always more or less prevalent in a place or community, it is said to be *endemic ;* when it becomes largely prevalent for a time where it previously did not prevail, it is said to be *epidemic ;* and when an epidemic is very widespread over a large tract or over the whole earth, it is said to be *pandemic.* Microbic diseases are nearly always endemic or epidemic in their incidence ; this is a natural consequence of their communicable nature.

The presence of endemic disease implies constant local conditions which favour it. The presence of epidemic disease implies at least the temporary existence of such conditions, and the importation of the specific virus of the disease, unless it was already present.

What the local conditions are which favour the existence of endemics and epidemics, and how they may be mitigated or removed, it is the practical business of the sanitarian to examine.

In the case of epidemics, moreover, where the disease did not already exist, it will be necessary to inquire into the methods of importation and spread. The first cases which occur are most likely to afford a clue, and no trouble should be spared in obtaining all possible information regarding them. Local insanitary conditions undoubtedly favour the spread of epidemics, and our first care should be to remove or mitigate them—we may thus prevent a disease from settling even if it be imported—but our second care, especially if local conditions are bad, should be directed towards preventing its importation, and isolating cases which occur.

The origin of epidemics of microbic disease is still in great part a matter of speculation. Why do

diseases which are endemic or sporadic sometimes exhibit an increase of virulence and a tendency to spread and assume the epidemic form? Why do epidemics spread from certain centres in a wave-like manner, being most severe and fatal at their first onset and gradually diminishing in intensity until they become extinct, except in endemic foci where they slumber? The starting point of epidemics has been attributed, with apparent probability, to the origin under favouring conditions of a brood of specific microbes possessing unusual vitality and virulence. Accidental hardy varieties in plants and unusually vigorous breeds of animals arise occasionally in an analogous way. Swarms of locusts or moths or other insects come into being when conditions have been peculiarly favourable for their development, but not otherwise. The conditions which give origin to epidemic "sports" in disease-microbes are unknown; but the marked effect which climatic conditions have been observed to produce upon epidemic diseases, points to the probability of such variations occurring during the growth of the microbes outside the body. The greater intensity of an epidemic at its onset, and its gradual decline and extinction, are usually explained by the theory that the most susceptible individuals are first attacked, and later on those who are less susceptible and who therefore do not suffer so severely and that, finally, the soil being exhausted, the disease dies out. If this be true, the spread of an epidemic from a centre may be aptly compared to the growth of certain mushrooms in gradually widening circles ("fairy rings"), according as they exhaust the soil of the nitrogenous nutriment which they require for their sustenance. It is probable that in areas where diseases are endemic, either the soil or the water or insects or animals form the natural habitat of the specific microbes.

In epidemic areas, on the other hand, into which a disease is imported and where it does not permanently establish itself, the contagium exists principally in the bodies of the infected individuals; if the soil and water become infected, they retain the infection only temporarily, as it tends to die out when its location is not suitable. Koch suggested that cholera microbes may ordinarily grow among decaying vegetation in such places as the Sunderbunds, and thence invade man. Although cholera has frequently been imported into Western Europe, it has never succeeded in permanently localising itself there.

Epidemics sometimes appear to arise spontaneously, that is, no importation can be traced. This is commonly owing to imperfect information, but it is occasionally due to latent foci of the disease existing in a place. It is possible that the specific microbes or their spores may have existed locally in a dormant condition, or at all events without invading the human body.

Epidemic diseases may be imported over and over again into a place; but, if local conditions be unfavourable, they will not extend.

Man can usually do little to alter climatic conditions, but he may often do much to alter other local conditions. He may keep the surroundings and interior of his dwellings clean and dry, thus arresting the local propagation of microbes and vermin, he may preserve his water and his food from defilement, he may strengthen his own body, so that it shall not be a ready prey for microbic invasion, he may isolate cases of disease and destroy the germs produced by them.

Epizootic Diseases.

Domestic and wild animals suffer from communicable diseases which at times are transferred to

human beings, and similar precautions have to be taken to prevent their spread, not only to avoid loss from the death of valuable beasts, but also to secure the safety of men. Amongst these epizootic diseases are rinderpest, anthrax, tuberculosis, rabies, foot-and-mouth disease or epizootic aphtha, actinomycosis, glanders and plague.

CHAPTER XIV.

PREVENTION OF COMMUNICABLE DISEASE.

Effective measures for the prevention of microbic diseases act (1) by depriving the virus of a soil suitable for its growth, (2) by excluding it, or (3) by destroying it. Under the first head, we shall notice the removal of conditions which favour the growth of microbes without and within the body, and protection by inoculation; under the second, the isolation of the sick; and under the third, the use of disinfection.

External Conditions which favour Microbic Growth.—These have already been alluded to when treating of soil, houses, removal of refuse, water, food, etc. Climatic conditions, such as moisture, warmth, and stillness of air, are to a great extent irremediable; but in climates where such conditions prevail, it is particularly necessary to pay great attention to dryness and purity of soil about houses, to cleanliness and free ventilation within them, to the speedy removal of all waste matters and to their disposal in the fields where they may be disintegrated by harmless microbes and be assimilated as plant-food. As previously mentioned, little is known regarding the external life of such disease-microbes as may live apart from the body; but it is certain that some may live apart, and in the absence of definite knowledge, it is safest to assume that others may likewise, and to take all possible measures to discourage such

growth. When it is remembered how many parasitic disease germs either pass a portion of their existence in, or are indirectly conveyed to man by, insects such as mosquitoes, bugs, fleas, ticks, flies, and the possible dangers arising from the near neighbourhood of rats, mice, bandicoots, dogs, crows and such like vermin, it is obvious that householders should take care that their houses and immediate surroundings are kept so clean and free from dust and dirt that insects cannot find place there.

The larger animals will not frequent a house in or round which they can find no food lying about.

Bodily Conditions which favour Microbic Growth.—Feeble vitality of the living tissues undoubtedly predisposes to the invasion of microbes. Even ordinary septic microbes may attack tissues which are dying or whose vitality is at a very low ebb. Previous good health and strong vitality do not, however, afford much resistance against the attacks of all pathogenic microbes, except by preventing their lodgement in the body. If the skin and mucous lining of the respiratory and digestive tracts be in a healthy and unbroken condition, most disease microbes may be brought into contact with them over and over again without being able to effect a lodgement. On the other hand, a scratch or an ulceration of the skin, in a previously healthy individual, may admit the microbes of many diseases, such as syphilis, tetanus, etc. Ulcerated conditions of the intestinal mucous membrane, such as are extremely common in India, produced by intestinal parasites or otherwise, may also admit various microbes* into the blood or tissues.

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* Including *actinomyces* and even *mycelial fungi*.

Inflammatory conditions of the respiratory mucous membrane, or inactivity of respiration due to deficient exercise or previous disease, may prevent the inhaled microbes of tubercle, pneumonia, etc., from being thrown off. There is some evidence that chemical alteration of the normal secretions, or of the blood or tissues, may dispose to microbic infection,* and there is no doubt that inherited weaknesses of certain organs may do so.

It is thus apparent that physiologically morbid states do predispose to the reception of microbic diseases, and thus preservation of the general health is one of the best safe-guards against them.

Health and disease are relative terms, it is hard to draw the line between them. Perfect health is an ideal state it is scarcely possible to attain to. The human body is so complex that some part is almost invariably disordered, and it is these excursions below "par" on the part of the different bodily functions which pave the way to the entrance of pathogenic microbes. For the prevention of disease in a scientific, that is, in the most rational and effective manner, the causes of disease must be known with accuracy. But knowledge of these causes is still very imperfect; the causes of some diseases have been ascertained with more or less exactitude; some other diseases, though not yet traced to their sources, are, by analogy, believed to be of a nature similar to better-known diseases, yet other diseases exist whose causes are still obscure.

The measures to be adopted to avoid infestation by the larger animal parasites have already been touched on in the chapter describing them.

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* For instance Koch found that his cholera bacilli were destroyed by the naturally acid gastric juice, but passed through the stomach unaffected when its contents were neutral or alkaline.

The lodgement of ectozoa, such as itch, acari and lice, may be prevented by cleanliness of person and clothing, and avoidance of contact with affected individuals. Clean dwellings ought to be free from fleas, bugs, and ticks; but it should be noted that fleas and ticks are apt to be introduced by domestic animals. The skin diseases due to the growth of parasitic fungi on and in the skin, which are so common amongst the poorer classes in India, can be prevented by due attention to cleanliness both of person and of clothes. Great care is now being taken at Indian ports which are used by vessels coming from Africa to prevent the introduction into India of "Pulex Penetrans" or the *jigger flea*, which has overrun Africa of recent years. The female of this flea bores beneath the skin of men and excites serious inflammation.

Entozoa are most commonly acquired by drinking polluted water containing their eggs or larval forms. Their eggs may also be conveyed on vegetables or fingers soiled with excrement containing them. Tapeworms are acquired by eating the under-cooked flesh of animals containing their larval forms; thorough cooking kills these. Trichina is acquired in the same way. An uncontaminable water-supply is the first essential for the prevention of all these parasites. All water which is not above suspicion should be well boiled to kill their ova or larvæ. Doubtful vegetables should be cooked, and suspected meat also, if eaten, should be well cooked.

The evacuations of persons affected with intestinal parasites should be burnt or buried deeply. Water polluted with such evacuations containing ova is the most fertile means of propagation of these parasites. Animals may also be infected by eating the excrement or grass which is soiled by it, and man by eating vegetables manured with it.

Lice in clothes may be destroyed by boiling. On the body it must be remembered that they leave their eggs attached to hairs, and, though the lice may be destroyed by mercurial ointment or otherwise, the eggs are hatched and give rise to a new brood at the end of five or six days.* Any parasiticide used must therefore be applied continuously for a week. The simplest and surest way to free the head is to shave off all the hair and burn it.

Itch is caused by the burrowing of a minute *acarus* in the skin. It may be seen with the aid of a lens, and is not uncommonly found in clothes. To prevent its recurrence, the application of sulphur, or whatever other remedy is used, must be continued for a considerable length of time in order to destroy the young acari, as they are hatched from the eggs which are left in the skin.

Protection by Inoculation.

Protective inoculation is an attempt to assist the tissues of the body in resisting the invasions of pathogenic microbes. Sometimes the chief effort must be made against the microbes themselves, sometimes against their toxins. As mentioned before, if a person has passed through an attack of a specific disease, his tissues have usually acquired the power of destroying the specific microbes of that disease if at a future time they enter his body. This is naturally acquired immunity. If it be desired to confer immunity artificially, to render the tissues antimicrobic, this may be done by inoculating the person with successive doses of the specific microbe, beginning with dead ones, or ones that are attenuated, that is, have had their virulence reduced, and proceeding to stronger doses of the fully virulent

* Lice are hatched at the end of 5 or 6 days and reproduce at the end of 18.—*Van Beneden.*

organism, until the subject can bear with impunity the introduction of a dose of the microbes into his system which would infallibly have killed him had he not been immunised by the previous inoculations. The tissues of such a person have become actively antagonistic to that particular microbe, and remain so for a varying length of time, during which he is not susceptible to an attack of the disease of which it is the causative agent. Haffkine's anticholera and Wright's antityphoid injections were made on this principle. A less complete and less durable protection can be afforded by the injection of only the toxins of the microbe which have been obtained by cultivating it in fluid media outside the body. The injected toxins stimulate the tissues to form antitoxic substances, which remain available for neutralising the toxins formed in the case of a subsequent accidental infection with the disease in question, but no antimicrobic substances are formed as microbes are not injected. Haffkine's plague prophylactic is obtained by a combination of these two methods. It contains the toxins of the plague bacillus formed during its cultivation in a fluid broth for six weeks, together with the dead bodies of the bacilli themselves.

Doubtless, before long, great progress will be made in the direction of similar protective inoculations. Success appears to be at present curtailed by the fact that there are many different varieties of each pathogenic microbe, each of which has its own special action in the body, and each of which forms toxins slightly different from those formed by other varieties or races. The result is that the protection conferred by the use of one variety or one toxin is not absolute when infection with another variety occurs, which produces a toxin which cannot be entirely fixed by the antitoxin elaborated by the tissues in response to the injections with the first variety.

The prophylactic treatment of rabies * which was initiated by Pasteur, differs from anti-plague, anti-cholera and anti-typhoid inoculations in that it is only performed after persons have been bitten by mad animals. The incubation period of rabies is usually sufficiently prolonged to enable a state of active immunity to be conferred on the person bitten, before rabies, or hydrophobia, as it is called when it affects man, has had time to develop. In the case of cholera, typhoid and plague, inoculation is practised among persons exposed to infection in order that they may be immunised and so escape infection. Inoculation is now largely practised amongst cattle to protect them from epizootic diseases, such as rinderpest and anthrax.

Another way of conferring protection is by inoculating the virus of the disease, after it has been modified and lessened in virulence by passage through an animal. This is done in the case of small-pox. The virus of small-pox is profoundly modified by passage through a calf, but when subsequently inoculated into a human being it gives as good protection as results from a previous attack of small-pox itself. This process is always styled "vaccination."

Inoculation of small-pox directly from person to person has been freely practised in past times in many countries, and it still goes on in certain parts of India and in Burma. The idea is that inoculation from a mild case of small-pox will only result in a mild case of small-pox, which will protect from possibly severe attacks in the future. Unhappily this expectation is not always realised, for sometimes death follows the inoculation. The practice is now forbidden by law everywhere, not only because

* Now carried on in India at the Pasteur Institute, Kasauli, Punjab, and the Pasteur Institute, Coonoor, Nilgiris.

death may follow, but because cases of the disease are actually multiplied, and so many fresh foci for starting an epidemic are brought into existence.

The practical application of protective inoculation is greatest in the case of small-pox, which is a world-wide, easily-spread and dangerous disease. Nowhere is a person safe from possible infection, and no means of protection is available but vaccination. The other diseases are less widely distributed and less easily communicated, and other ordinary precautions may be sufficient to guard a man. Hence inoculation is only resorted to in times of severe epidemics when whole towns are exposed equally to the risk of infection, as in plague; or when a man is going to a district where some disease is prevailing, *e.g.*, typhoid fever, or after actual infection, as in rabies.

Isolation of the Sick.

The advantage of limiting a communicable disease by isolating persons suffering from it is obvious, and has been recognised from ancient times. But isolation is not equally useful or practicable in all cases of communicable disease, and the manner and degree in which different microbic diseases are communicable must be taken into account in devising measures for their limitation. Some like small-pox, whooping-cough, dengue and mumps, are easily and usually communicated, for some distance, through the air, as well as by contact of persons or infected articles. A second group, containing diseases such as tuberculosis and pneumonia, appears to be less readily communicable. A third group, comprising cholera and enteric fever, is communicable rarely, if ever, through air, but usually in drinking-water and probably in food; while a fourth group of diseases, such as syphilis, rabies and probably leprosy, appears to be communicable

only by inoculation. Malaria stands by itself, as it is only communicable from person to person through the intervention of the mosquito.

It is in the case of the first of these groups, which contains what are commonly known as "infectious diseases," that isolation is particularly efficacious and desirable. It is so to a lesser degree in the second group. In the third group, other measures, such as disinfection, cleanliness and preservation of water and food from infection, are most useful, isolation being unnecessary if they are strictly attended to. In the fourth group isolation is useful, but, owing to the chronic nature of some inoculable diseases, it may be difficult or impracticable to enforce it. Individuals may generally, however, protect themselves from such diseases by avoidance of direct contact with the affected, especially of such contact as may lead to inoculation at any abraded or mucous surfaces.

It is evident, therefore, that isolation is most practicable and useful in those *acute* diseases which are ordinarily communicated by *aerial infection*, but the best manner of carrying out such isolation is not always apparent. Is all communication with sick persons and their households to be cut off? Are travelling and commerce by sea and land to be hampered or arrested by the restrictions of *quarantine*? Are the sick to be secluded under medical care in their own houses, or are they to be removed to special hospitals?

The first-named method of isolation by "boycotting" would, in most cases, be inhuman and barbarous, nor would it often be possible to carry it out effectively.

Quarantine, in the modern acceptation of the term, means arrest of communication with infected places, except under certain restrictions. These usually consist in detaining healthy travellers for a specified

time after their departure from an infected place, and travellers among whom the disease has broken out for a specified time after the occurrence of the last case of disease among them, on board ship or in a place (lazaretto) set apart for the purpose. The time of quarantine should cover at least the longest known period of incubation of the disease. Merchandise is also, if admitted, sometimes subjected to some process of disinfection, and the importation of particular articles, such as rags, may be prohibited.

In theory, quarantine would seem to be an effective way of excluding communicable diseases; but actually it has nearly always failed to do so. It was practised extensively during the great epidemics which devastated Europe during the middle ages; but it signally failed to check them. It has, in more recent times, as constantly and conspicuously failed.

The reasons for such failure are numerous. The period during which infection may last being much longer in some diseases and of more uncertain length than the period of incubation, persons among whom the disease has occurred, and possibly those who have been kept in contact with them, as the healthy are with the sick during ordinary quarantine, may carry infection for a longer period than can well be covered by quarantine. Quarantine usually interferes with food supplies, and it may thus cause privation and predisposition to disease; and by checking commerce it alters prices and affords strong temptation for its own evasion. The police or troops employed as quarantine guards cannot always be depended on; even if reliable it is difficult for them in all cases, impossible in most, to arrest all communication, and they themselves are exposed to hardship and are likely to contract and spread the disease.

The imprisonment of healthy and sick together in a lazaretto is not only barbarous, but tends to

keep the disease alive. Money is thus wasted on measures which are worse than useless when it might be usefully employed. These are some of the direct evils of quarantine. Indirectly its effect is equally pernicious: disease is concealed owing to the fear of quarantine; when it is imposed, the people, relying on the ostentatious measures taken for their security, encourage disease by neglecting local sanitation, and give way to panic when the epidemic breaks through their futile "sanitary cordon" of police and soldiers. Microbes must be met with other weapons than bayonets.

Land quarantine may therefore be regarded as impracticable, and least likely to be efficient in populous places, where presumably it is most needed. Sea quarantine may be useful in some cases if administered intelligently, but it scarcely concerns us here. In any case it should not be imposed for a longer period than the longest incubation time of the disease, after sailing from the last infected port or after the occurrence of the last case of the disease on board; and, for reasons given above, it should by no means supersede or dispense with the usual precautions of medical inspection.

Though quarantine, as such, is inadmissible, yet much may be done by individuals and by bodies, such as troops or students, subject to discipline, to avoid infection. Thus the public should be warned of the prevalence of communicable disease in particular localities, and persons under control may be prevented from visiting such places. When epidemic disease exists, movements and assemblages of population should, as far as possible, be restricted, and marches of troops, fairs, and pilgrimages be prohibited, or at all events carried out with special precautions, and schools may be closed with advantage in some cases.

A modified system of quarantine, especially in countries such as India, is not only justifiable but is of the utmost value when combined with an efficient system of observation, and it can equally well be applied on a land frontier, a sea board, and within the limits of a country. Such a system is now imposed in India to control the spread of plague. It has been particularly carefully worked in the Madras Presidency with most satisfactory results. Briefly, it consists in making all arrivals from an infected district take out passports which bind them to present themselves for inspection daily for a period of 10 days. Persons who appear to be suffering from plague are at the same time detained and isolated, and beggars and loafers, who can give no address and who cannot be relied on to report themselves, are also liable to detention. If a passport-holder fails to report himself he can at once be hunted up and safely dealt with if found to be suffering from plague.

Though this system is by no means infallible, still it affords a large measure of protection and is not disagreeable to the public, as may be gathered from the fact that it has been in force in Madras City for over eleven years, and that during that period only from 3 per cent. to 6 per cent. of the passport-holders escaped observation in different years.

A similar system of medical observation, combined with disinfection of ships, is carried on in England in connection with ships coming from infected ports or having cases of infectious diseases on board.

When an infectious disease breaks out in an army or in a body of workmen or prisoners, it may occasionally be possible to resort to the plan of isolation by groups, such as is practised in the extirpation of cattle diseases. The body is

sub-divided into a number of smaller groups, which are kept separate. When any of these groups have been free from the disease for a period equal to its longest incubation time, they may be passed as safe and not likely to spread infection.

Isolation Hospitals.

In all large towns it is necessary to provide hospital accommodation for the isolation and treatment of cases of infectious disease. In England the standard aimed at is one bed for every 1,000 inhabitants, but this is beyond the means and even outside the requirements of Indian towns. The essential features of an isolation hospital are a well-drained healthy site, well away from crowded localities, yet not so far as to be inconvenient; separate wards for each infectious disease to be admitted, (in practice these are generally limited in India to small-pox, cholera and plague. Typhus, relapsing fever, typhoid, measles and chicken-pox are more rarely dealt with thus, and lepers are generally otherwise provided for), ample air space and floor space in the wards; proper arrangements for dealing with infective excreta and the disinfection of clothing and bedding. Hospital attendants should remove all their clothing before leaving the premises, and put on clean disinfected articles. One or more ambulances should be kept in all towns for the purpose of removing sick persons to isolation hospitals, but there is no objection to the use of a country cart, provided that it be disinfected before leaving the hospital. It is usual in Europe to have separate hospitals for small-pox, to avoid the risk of persons admitted with other diseases contracting small-pox, if there be a small-pox ward in the general infectious diseases hospital. It has not yet been proved beyond doubt whether the virus of small-pox is air borne to such an extent as to render

it dangerous to live within half a mile of a small-pox hospital, as has been maintained. It seems more reasonable to believe that the disease is disseminated by the hospital attendants when out on leave.

Compulsory Notification of the occurrence of infectious disease is a measure which can only be made effective when medical practitioners are liable to a penalty for not reporting any cases which come to their knowledge. The general public in India cannot as yet be penalised for failing to recognize an infectious disease, though they are usually quite aware of its nature. The advantages of compulsory notification are :—

(1) The sanitary officials are enabled to take immediate steps to prevent the spread of infection by the isolation of the patient, and disinfection. In the case of small-pox they can procure the vaccination or re-vaccination of all persons who have been exposed to infection and, generally, can limit the spread of infection by keeping children from school and adults from workshops.

(2) The medical officer of health is enabled to accumulate accurate information concerning the local, seasonal and epidemic occurrence of diseases, the value of which cannot be over-rated.

(3) The causes of the outbreak can be investigated with a greater chance of success if the earliest outbreaks are known.

The first essential is that immediate notification of all cases of infectious disease should be given to the local sanitary authority. This authority should then be prepared to adopt immediate measures for the seclusion of patients at home, or for their removal, with due precautions, to a properly appointed special hospital. Immediate notification of all cases of infectious disease may enable the sanitary authority not only to isolate the sufferers so as to prevent their becoming centres for the

dissemination of the disease, but also possibly to trace the original source of the disease and take effective measures for its suppression. Wealthier patients may be effectively isolated and treated in their own houses; but in the case of poorer patients it may be difficult or impossible to secure proper isolation and treatment without removal to hospitals. Poor people can not only be better isolated in hospitals than in their own houses, but they obtain greater comfort when they are sick. When they object to such removal, efforts must be made to isolate them as well as circumstances will allow.

Notification of disease is still in process of development in England. The more serious communicable diseases are compulsorily notifiable everywhere, and local authorities may extend the compulsion temporarily or permanently to any disease not on the general list if it appear advisable. The persons required to notify to the Medical Officer of Health are (1) any relative or person in attendance on the sick one, or, in default, any occupier of the building, (2) every medical practitioner called upon to visit such a case.

In India there is no notification at all. Although no doubt matters are not yet sufficiently advanced for a perfect system—still, in large towns which have health officers and a sanitary staff, much might be done. In Madras City, for instance, the Municipal Act enjoins all medical practitioners to report infectious diseases, but there is no penalty for failing to comply. Hence not even the payment of a fee for each notification secures much information. Not only should medical practitioners be made legally responsible and a penalty laid down, but each large town should maintain a register of qualified practitioners who should be bound to fulfil their duty to the community in this and other ways.

Universities too should look to their fair fame and acquire power to deprive any of their graduates of their degrees if convicted of unbecoming conduct.

Home Isolation.

For the isolation in their houses of persons suffering from infectious diseases, the following points require particular attention:—

(1) All unnecessary furniture and clothes should be removed from the room.

(2) A sheet soaked in a disinfectant, such as 1 in 20 solution of carbolic acid, should be hung over the door as a curtain. The sheet may serve some useful purpose in arresting contagion in the case of air-borne diseases, but it acts even more effectively as a danger signal to warn off intending visitors.

(3) The windows of the sick-room should be kept open as much as possible, in fact a person suffering from any communicable disease should be kept practically in the open air night and day.

(4) The attendants should, if possible, be selected from among persons who have already had the disease, or have been exposed to it without contracting it. They should avoid communication with other persons unless they have previously washed and changed clothes. All unnecessary articles, including change of clothes, should be removed from the room which the attendants habitually occupy. The clothes which they wear in the sick-room should be non-absorbent and readily washed. They should dip their hands in a disinfectant liquid (corrosive sublimate 1 in 1,000 or carbolic acid 1 in 20) on leaving the room. Their soiled clothes should be immersed in a disinfectant solution and afterwards boiled.

(5) Visitors should not be allowed to enter the room; but, if necessary, should only speak to the sick person through the curtain at the door or

through a window. Other residents in the house should avoid contact with the attendants. Children, if they remain, should not be allowed to go to school or mix with other children.

(6) Excreta and remains of food should be received in a vessel containing some strong disinfectant and be afterwards buried.

Excreta, however, are not easily disinfected by fluid disinfectants; it is better therefore to mix them with sawdust and burn them at once, or put them into a large vessel containing boiling water.

(7) Soiled linen should be placed in a disinfectant solution and be afterwards boiled.

(8) When danger of infection is believed to have ceased, the patient should be well washed, bathed with a disinfectant lotion, and have a complete change of clothes before he is allowed to mix with others.

(9) The room must be thoroughly disinfected after the patient has vacated it.

(10) No remains of food or drink should be allowed to leave the sick room. Anything that is not eaten or drunk should be destroyed by fire, or boiled or mixed with disinfectants.

(11) In case of death, the body should be completely enveloped in a sheet soaked in corrosive sublimate or strong carbolic solution, and be buried or cremated as soon as possible.

It is scarcely necessary to remark that, even if the patient and family give the most willing assistance, it must be extremely difficult to carry out all these precautions thoroughly in a private house, and that even in a hospital it may be possible to do so only partially. Sanitary officers should, therefore, endeavour to induce patients and their friends to consent to their removal to hospital, where they will probably be better cared for, and be less dangerous to their families and neighbours than if they remained in their own homes. It must always

be borne in mind, however, that even very imperfect and incomplete isolation is better than none, and may do a good deal in checking the spread of communicable diseases.

INCUBATION PERIOD.

The periods of incubation and infectivity are manifestly of much importance in considering measures for the suppression of infectious diseases. The following statement shows the period of incubation (time from reception of poison until the disease appears) and the duration of communicability of some of the most important microbic diseases so far as they are known. Practically "the power of imparting infection begins with the first symptom and lasts until the patient has absolutely recovered," that is, until "all special appearances of his disease shall have disappeared".*

Diseases.	Period of Incubation.	Period of Infectivity.
Small-pox ...	12 days	6 weeks usually.
Chicken-pox ...	10 to 12 days	3 ,, ,,
Measles	8 to 12 days or more .	4 ,, ,,
Dengue	3 days, may be 5 or 6 ...	2 ,, ,,
Mumps ...	10 to 22 days	3 ,, ,,
Whooping-cough.	4 to 14 days	8 ,, ,,
Influenza ...	A few hours	1 or two weeks.
Gonorrhœa ..	4 days usually, may be 1 to 8 days.	3 weeks or longer.
Diphtheria ...	1 to 8 days	6 weeks usually.
Relapsing fever ..	A few hours to 12 days, commonly 5 days.	4 ,, ,,
Enteric fever ...	5 to 21 days, commonly 11.	6 ,, ,,
Cholera	A few hours to 5 days .	2 ,, ,,
Malaria	1 to 3 weeks	Not transmissible from person to person except by transfusion of blood.
Plague	3 to 10 days	3 weeks or more.
Tuberculosis ...	3 weeks	Indefinite.
Syphilis	6 weeks	

The length of the incubation period of any microbic disease depends partly on the dose of the poison entering the system at the time of infection and partly on the resistance offered by the individual. The length of the period of infectivity depends on a variety of circumstances, which differ in each case. It has recently been shown that in the case of certain diseases, *e.g.*, typhoid and cholera, virulent bacilli continue to be discharged from the body for a very much longer time than it used to be thought, even after apparently perfect recovery. Hence such a person becomes a real source of danger to the community for he may go about spreading the germs of the disease for months after he has been restored to apparently perfect health.

The probability is that in the past too much attention has been concentrated on the possibilities of the spread of infective germs by inanimate objects and too little on the living carriers of the germs, namely the patient and those who have been in contact with him. The latter may become germ distributors even without showing signs of infection in their own persons.

CHAPTER XV.

SPECIAL DISEASES.

The principal diseases which a sanitary officer in India has to deal with must now be considered in greater detail, for the purpose of indicating the ways in which they are spread, and the preventive measures which can be reasonably undertaken to limit them. It is an error to assume that every one must pass through attacks of the commoner and milder infectious diseases either during childhood or at some period in life. It is true that some of these diseases are so common that scarcely any one altogether escapes them, but to wilfully expose a child to the infection of measles, let us say, in order that he may be attacked and immunised for the rest of his life is a criminal practice, and one that may have serious consequences, for no one can tell beforehand whether the attack will be mild or severe. Moreover, although an attack of some of these diseases often seems to immunise a person for life, it is not always so: measles, small-pox and enteric fever may all occur more than once in a lifetime.

MALARIA.

Malaria is by far the most important disease to be dealt with not only in India but also in all tropical countries. The annual mortality due to malaria in India exceeds by far that of any other microbic disease, but for every death that occurs there are many more attacks, representing an incalculable amount of suffering, loss of working power, and individual and racial deterioration.

The following table shows the number of deaths and the death-rates per 1,000 of population recorded in British territory in India during 1908:—

Cholera.	Small-pox.	Fevers.	Dysentery and diarrhœa.	Plague.	All causes.
591,725 2·61	170,694 0·75	5,424,372 23·96	285.921 1·26	113,888 0·50	8,653,007 38·22

It is evident that, even allowing a very considerable margin for other diseases being included under the vague heading of "Fevers," malaria works far more havoc than either plague, cholera or small-pox.

Its wide-spread occurrence and long familiarity with all its phases, cause people to view its inroads with an equanimity that fails them when they are confronted with a comparatively new disease like plague, and it has come to be regarded as a necessary evil.

Recent researches have proved that if malaria cannot be exterminated over large tracts of country, it can at least be rendered a rarity in large towns and kept under control in villages; also that any person who observes proper precautions can travel through, and live in, the most malarious district without taking any harm. The old theory that malaria, as its name implies, was in some way due to breathing bad air, has had to be abandoned, and there is no evidence, which can be accepted without hesitation, in favour of the view that bad water is in any way concerned, though many are unwilling to entirely give up this notion. Malaria has been shown to be due to the presence of a parasite which can be demonstrated in the blood of those suffering from the disease. In its human host this parasite can live and multiply asexually for considerable periods, but if its host does not succumb the parasite

itself dies in course of time. It cannot transfer itself directly to another person under ordinary conditions, but if the blood of an infected person be injected into the veins of a healthy one, the latter also becomes infected.

Ross, working out Manson's hypothesis, first made clear how the infection is carried in nature. He found that if mosquitoes of the genus *Anopheles* bite an infected person when the parasite is in a particular stage of its development, both the parasite and the blood pass into the mosquito's stomach, where the former continues its developmental cycle sexually, giving rise to a body termed the *zygote*, which attaches itself to and grows in the stomach wall of the mosquito. In ten days or more, according to the temperature, the zygote reaches its maximum size, bursts, and sets free a vast number of minute *sporozoites* in the body cavity. These find their way into the salivary glands of the mosquito, which are connected with its biting apparatus, and are injected, when the mosquito feeds on other people, into their blood, and so fresh attacks of malaria are started.

It cannot yet be stated as certain that there is no other means by which malaria may be spread, but it is established that the mosquito is the commonest way.

Knowing the causation of the disease and the way it is spread, it is easy to see how it can be prevented. We may either attack the parasite as it circulates in the blood of the man, or prevent the mosquito biting the man, or destroy the mosquito at some period of its life, or do away with the conditions which render it possible for the mosquito to breed.

But first it is necessary to learn as much as possible about the habits and life history of the members of the group of insects named Culicidæ, which includes mosquitoes and this can only be

done by actual observation out of doors, and by breeding them up in confinement. Attention will only be drawn to the three genera *Culex*, *Anopheles*, and *Stegomyia*.

Only female mosquitoes suck blood. Males may be distinguished from females by their thick feathery antennæ. All mosquitoes lay eggs on water, which hatch, and larvæ emerge. The larvæ feed greedily on vegetable matter and minute living forms in the water, cast their skins several times and finally turn into pupæ or nymphæ. A pupa does not eat, and in the course of a day or two bursts open, and the fully developed mosquito, or imago, comes out and flies away. Mosquitoes cannot breed in trees or on damp ground or anywhere except in water. They can, however, breed in the rain water which collects in the stumps of broken or cut bamboos, in hollows of trees, and in the axils of large leaves, and thus may abound in an apparently waterless jungle.

Distinguishing characters of

—	Anopheles.	Culex.
Egg or ovum.	Laid separately usually. Found in tanks, wells, irrigation channels, paddy fields, rain water puddles, pools in river beds, &c.	Laid in boat-shaped masses. Found in same places as anopheles, but also in pots, tins and collections of dirty water in and near houses.
Larva ...	Has no respiratory tube. Floats horizontally.	Has a conspicuous respiratory tube. Appears to hang at various angles from surface of water.
Pupa ...	Not easily distinguished.	
Imago ... M. and F.	Is generally straight. Rest at varying angles with a vertical wall. Wings spotted, barred or deeply coloured.	Is hump-backed. Rest parallel with a vertical wall. Wings clear, unspotted, except in one or two rare species.
Male.	Palpi bulbous at ends, same length as proboscis.	Palpi feathered at ends and pointed, longer than proboscis.

Stegomyia resembles Culex in the above characters. It is distinguished by the microscopical appearance of its scales. It is the common black and white "tiger mosquito," plentiful both in habitations and jungles, and it feeds voraciously by day.

A little practice enables Anopheles and Culex to be distinguished from each other and from all other kinds of two-winged flies without fail. A microscope is necessary to differentiate the numerous species of Anopheles and Culex, but observation and a hand lens will go a long way.

As far as is yet known only Anopheles can carry malaria; and the researches of the Indian Malaria Commission tend to show that though all the species of Anopheles can be experimentally infected, yet in nature it is probable that the commonest species, such as Anopheles Rossii, do not function as carriers. In the most malarious places it is seldom that more than 6 per cent. to 8 per cent. of infected insects are found amongst the species that do carry. The prevalence of malaria in any area is judged by the percentage of young children under 5 who are found to have the parasite in their blood, and the percentage of the population, taken in 10-year age periods, who have enlarged spleens. As the years go by, those who do not succumb to the malarial infection appear to acquire a relative immunity, but this applies only to places where the chances of repeated infection during childhood are very numerous.

In places where malaria is not very prevalent, and the chances of infection are not numerous, age confers no sort of immunity. It is possible that amongst other things malaria is responsible for a good deal of the chronic kidney disease which is so common in India.

Anopheles do not seem to fly further than from $\frac{1}{4}$—$\frac{1}{2}$ mile from their breeding places as a rule:

a belt of trees between a village and a breeding ground probably arrests the progress of the majority of mosquitoes.)

Preventive Measures.—Destroying the parasite in the blood by the administration of quinine is obviously an impracticable measure to apply to an undisciplined population. It is of value in connection with bodies of men under control.

Quinine is invaluable as a prophylactic against malaria, not for daily use over long periods, but taken in doses of 15 grains each twice a week, when exposed to infection in travelling in malarious districts. As a curative agent it is generally given in too small quantities and for too short a time. Adults can take 20—30 grains daily until the fever has ceased, then 10 grains every second day for a week longer. Relapses are not infrequent even after a course such as this. Doses of less than 10 grains are useless for adults.

Protection of the body from bites is largely a matter of personal care. The intelligent use of mosquito nets at night and the avoidance of bites after sunset and before sunrise will save a man from many an attack. Mosquito proof houses are not likely to be often seen in a hot and poverty-stricken country like India, but those who can afford it would derive considerable safety and much comfort from a wire gauze protected room in a verandah for sitting in after dark.

The destruction of adult mosquitoes is neither an easy nor satisfactory way of dealing with the matter. Far simpler and more effectual a plan is to hunt out the breeding places and see if they can be filled up or drained. Much can be done in a town in this direction by filling up or draining puddles, ditches, low ground, old wells, dirty pools and tanks. Mosquitoes of all kinds are a pest, even

if not actually dangerous, and measures undertaken in a town or village to exterminate Anopheles should be understood to include Culex and Stegomyia also.

Mosquitoes in houses are no more a necessary part of life in the tropics than flies ; both are dangerous, both indicate defective sanitation, though in different directions, and the presence of both points frequently to culpable carelessness either on the part of the house-owner himself or of his immediate neighbours.

Wet cultivation within town limits and in the immediate vicinity of villages should cease.

Larvæ can be readily destroyed by the application of kerosine oil to the surface of a well or puddle. The oil forms a film on the surface and obstructs the respiration of the larvæ which consequently die. Practically it is often difficult to get the oil to spread satisfactorily. Much agitation of the water and painting the surface with a mop aids the formation of a film. This is of course only a temporary measure, and has to be repeated at suitable intervals of a few weeks, whenever fresh broods of larvæ have hatched out.

Extensive drainage of the subsoil may, by lowering the water level, keep certain places dry which formerly served as breeding-grounds; conversely, works which obstruct the flow of the subsoil water and too free irrigation may increase the amount of malaria.

In the absence of suitable breeding places Anopheles cannot exist, and hence there is no malaria. There may be both men, breeding places and Anopheles, and yet no malaria, because there are no parasites. If parasites are then introduced by the arrival of an infected person, malaria will take root and spread if the climate be favourable.

If the climate be not favourable the infection will not spread. In the light of this knowledge common sense will enable a reasonable explanation to be found for most of the problems which arise in connection with malarial infection, and will suggest what combination of preventive measures is likely to be most effective and at the same time most acceptable to the populace which is being dealt with.

CHOLERA.

Cholera is a disease which has its home in India, being endemic in Lower Bengal: many other districts, including the Madras Presidency, are never entirely free from it. It is generally admitted to be due to the presence of Koch's comma—bacillus in the intestine. This microbe or vibrio generally obtains entrance into the body with excreta-contaminated water or food. It is capable of rapid multiplication outside the body in water and damp earth, but certain common saprophytes are antagonistic to its growth. It does not form spores and is readily destroyed by drying. A high temperature is necessary for its growth. It is kept alive in the moist soiled clothes of cholera patients, and was found by Koch in the water of a Calcutta tank, where such clothes had been washed, and which was being drunk by people among whom the disease was epidemic. Sand obtained from a river-bed which had been fouled with cholera excreta was used in a filter at Lucknow, and caused an outbreak in a British Regiment. The vibrio varies greatly in virulency from time to time. It has several times been isolated from the evacuations of healthy persons, and also some while after recovery from an attack.

During an epidemic, diarrhœa is generally found to be also unusually prevalent, and it is probable that numbers of these cases are really mild attacks of cholera.

The mortality varies from 30 per cent.—50 per cent.; in limited outbreaks it may be much higher. It is quite possible that the very mild cases are as dangerous to the community as the fatal ones, and that water contaminated with their excreta will convey the infection equally well. The vibrios are also present in the vomit of cholera patients.

Predisposing causes are fatigue and depression, combined with want of food. It is probable that the vibrios will not cause an attack if they pass into a perfectly healthy stomach and intestine. Fear may predispose but cannot cause an attack in the absence of the causative microbe, nor need any hesitation be felt in entering a cholera house: the disease cannot spread through the air.

The disease prevails chiefly in crowded parts and in the most insanitary areas. It attacks most readily beggars and chronically under-fed and, therefore, unhealthy people. In times of famine, especially, it runs riot.

Its *seasonal prevalence* varies with the local conditions. Before the rains, when water is scarce, contaminable sources may be drawn upon, which are usually untouched, and an epidemic may result. In Madras City, cholera almost invariably begins at the end of July or in August, when light showers have fallen, which may have washed foul matter into wells. Heavy rain on the other hand sometimes stops an epidemic, though it may increase again afterwards. In Madras Presidency it appears to reach its maximum rate of mortality between June and September in those districts which receive a South-West Monsoon, and during October, November and December in those which get the North-East Monsoon. Nothing really definite is known about the seasonal influences which determine the spread and cessation of epidemics of cholera.

Mode of infection.—The conveyance of cholera by men from place to place is a certain fact. It does not travel faster than men can travel, and invariably spreads along railway lines, rivers, canals, and from port to port: always on the great lines of communication. It constantly breaks out among the crowds who congregate at fairs and pilgrimages, and is frequently carried through the country by infected parties of them as they travel to their homes.*

As to the communicability of cholera by water soiled with cholera excreta, the first well-investigated cases were recorded by Dr. Snow in 1849 and in 1854 in England, and since then very numerous instances have placed the matter practically beyond doubt. In 1886 cholera was largely prevalent in Calcutta, and it was found that most of the cases took place in those localities where the public water-supply was most deficient and that a large grouping took place round tanks. Its conveyance by food is probably less frequent. An epidemic once occurred among persons who partook of rice which had been spread on a mat in a hut where a man had died from cholera. If infected articles may convey the disease, it must be possible for healthy persons to convey it on their clothes or bodies. Investigation into the 1909 outbreak in the nurses' quarters of the Presidency General Hospital, Calcutta, showed that the virus may travel from the bowels of apparently healthy men to their hands during the process of ablution after defæcation, from their hands to articles handled by them, to food, water, ice, vessels in which food is

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* Its propagation by persons from Hurdwar fair is the most often cited instance, and Dr. J. M. Cunningham himself stated "that the cholera went with the pilgrims in every direction is a fact which admits of no dispute." Pilgrims from the Tirupati and Periyapalaiyam festivals are well known to be frequent carriers of cholera to Madras and other places.

kept, and to stored filtered water by way of the dipper. Flies probably take an important part on occasions in the dissemination of cholera. Not only can they carry the microbes on their feet from latrines and cholera houses, but their excreta also contain the vibrios in a virulent state after they have been feeding on cholera dejecta.

Prevention.—General sanitary measures conducive to purity of earth, air, dwellings, food and water are most effective. Purity of water is particularly important, and a town which has a water-supply above suspicion is scarcely likely to suffer severely from cholera. If cholera actually breaks out in a town, all sources of water should be looked to and suspicious ones abandoned, wells should be treated with potassium permanganate and all water used in the house should be boiled. Great attention must be paid to the careful removal of rubbish and filth, and, as a personal precaution, every care should be taken to avoid any gastric irritation, or disturbance of digestion, by eating unripe or overripe fruit or anything that is known to disagree. A surfeit of melons or jack fruit cannot give cholera but it may pave the way for an attack.

Isolation of the sick is important, and a hospital is preferable to a private house both for the sake of the patient and because gatherings of sympathetic relatives, which are often followed by injudicious feasting, do not then take place in the infected house, and one frequent method of dissemination is thereby avoided. The excreta must be carefully disinfected and should on no account be put in the common cart, or even a sewer, without having first been rendered harmless by being received into a vessel containing disinfectant and afterwards boiled, or by being mixed with sawdust and burnt. All soiled clothes and rags should at once be placed in disinfectant or in boiling water, and liquid disinfectants should be freely used on the floor and walls

near the patient. Attendants must be careful not to infect themselves by eating food with excreta-soiled hands. With care they should run no danger.

No food and drink should remain in the sick room, and none which has been in the room should be tasted by others: it should be destroyed. Milk is particularly liable to contamination. All cold food should be avoided by other members of the household.

At fairs, festivals and other large temporary gatherings the local authority should make due provision in advance for an uncontaminable supply of water, for sufficient latrine accommodation, and for separation of the sick in case of cholera occurring. Such precautions are necessary not only at the centre of attraction but at the halting places on the routes leading to and from it.

SMALL-POX.

Small-pox is a no less preventible disease than cholera, and it is more loathsome and the cause of more suffering, although neither its absolute nor its relative mortality is so great. The death-rate from small-pox in India varies from 0·3 to 2·0 per 1,000 per annum, and about 20 per cent. of the persons attacked die. It is essentially an epidemic disease, though it must be regarded as endemic nearly everywhere in India, and severe epidemics of it recur generally at intervals of 5 years. In London, in 1771–80, small-pox caused 10 per cent. of the total deaths, in 1831–35, 2·7 per cent. and in 1861–70 only 1·1 per cent. (0·2 per 1,000 of population). It may thus be seen that before the introduction of vaccination, small-pox was more fatal in London than it is now in India, while at the present day it is very much less so. The contagium of small-pox is very persistent, and it may act through a considerable distance.

Power's investigations in England go to show that the virus of small-pox can be carried through the air for a mile at least, and that houses within a radius of half a mile of a small-pox hospital have been attacked at three times the rate of those between half a mile and a mile, and at four times the rate of those beyond a mile. While the ærial dissemination of small-pox to this extent does not meet with universal acceptance, it is a sound rule in default of exact knowledge to locate small-pox hospitals as far from inhabited areas as is practicable.

In addition to ærial convection, the virus of small-pox may be conveyed by the clothing of the sick man, particularly if it be sent out to a dhoby, by vehicles in which he may have travelled, and by the clothes of persons who may have been in contact with him. Flies, too, possibly play a part.

One attack of small-pox generally protects for life, but second attacks are not very uncommon, and the protection afforded by an attack tends to wear off in course of time.

Nature of Small-pox.—Small-pox is a typical acute microbic disease. It is peculiar to man, though several other animals suffer from closely similar diseases. The microbe has not yet been isolated, but it is probably an organism allied to the protozoa and not a bacillus. For the sake of convenience, cases of small-pox are divided into (1) discrete, in which the pustules are separate from one another, (2) confluent, in which the pustules are so closely packed that they touch one another, (3) malignant, a rapidly fatal form, (4) modified, in which the course of the disease and the appearance of the eruption is modified by previous vaccination. Small-pox, besides facial disfigurement, is responsible for the greater part of the blindness and deafness met with in India, and the great reduction during the last 30

years in the number of the blind, as ascertained by the census returns, is to be attributed to the reduction of small-pox by vaccination.

Prevention of small-pox.—Under this head we shall consider (1) isolation and disinfection, (2) inoculation and (3) vaccination.

Isolation and Disinfection are undoubtedly efficacious, but it is difficult to carry them out thoroughly. Small-pox hospitals should be as far as possible from dwellings, and every precaution must be taken to prevent the spread of infection by attendants and servants, as well as by other means. Air infection in the neighbourhood of a patient can be prevented by smearing the body freely with an antiseptic ointment such as—

Salicylic acid	..	...	3	parts.
Starch ...	...	...	30	,,
Glycerine	...	...	70	,,

every four hours, in order to prevent dry particles derived from the skin being carried about by the air.

Inoculation—first practised in Eastern countries—was introduced into England from Turkey in the first half of last century. It is even now unfortunately practised by a few ignorant persons in India and is quite popular in Burma. The inoculated disease is much milder and much less fatal than the naturally acquired disease, and it produces immunity from a second attack; but it diffuses the contagium of the disease and renders the latter more difficult to stamp out, while it adds greatly to the danger of the many who do not submit to the operation. Inoculation of small-pox is then strongly to be condemned, mainly because it diffuses the disease we want to suppress.

Vaccination.—Dr. E. Jenner, in the year 1798, first published an account of the great discovery.

For many years previously he had been making observations, but he had great difficulty in obtaining acceptance for his views. When put to the test of experiment, however, they speedily triumphed, and in a few years vaccination became very general among all civilised nations. There was a popular belief in some parts of England that persons who had suffered from "cow-pox,"—sores which sometimes appeared on the hands of milkers who milked cows suffering from a certain eruption on their teats—could not get small-pox. Jenner investigated this belief and concluded that it was founded on fact. At length he inoculated a boy with the cow-disease and found that he was then proof against small-pox inoculation. He also discovered that the cow-pox could be transmitted from person to person by inoculation. The advantages of vaccination over small-pox inoculation are that it affords similar protection with absolute safety, that it does not propagate a dangerous disease, and that it ought to enable us eventually to extinguish small-pox altogether, though it is doubtful if this consummation would be quite popular with the devotees of Mariamma.

The protection which vaccination affords against small-pox is manifested in two ways; firstly, by the immunity from that disease which, as a rule, it confers; secondly, by the modification which, when immunity is not complete, it induces in the course and severity of the disease.

It must, however, be remembered that the protective effect of vaccination is both less perfect and less permanent than an attack of small-pox, so, while infantile vaccination reduces the incidence of the disease in childhood, it has less effect as years go on.

The degree of protection afforded by vaccination depends mainly upon (1) the time which has elapsed

since its performance and (2) the mode of its performance—the protection given by vaccination in three or four places being much more perfect than that conferred by vaccination in only one spot. The comparative and absolute immunity from the disease, and the greatly lessened mortality when attacked, as well as the value of vaccination at several points, have been shown by abundant statistics.

The following are Dr. Marson's well-known statistics (5,000 cases):—

(1) Unvaccinated, mortality per cent. ..	35·00
(2) Stated to have been vaccinated, but having no cicatrix	23·57
(3) Vaccinated—	
(*a*) Having one vaccine cicatrix	7·73
(*b*) „ two „ cicatrices ..	4·70
(*c*) „ three „ „ ..	1·95
(*d*) „ four or more vaccine cicatrices	0·55

The operation of vaccination consists in the insertion of vaccine lymph into punctures made in the skin, or rubbing the lymph into abrasions made by scraping the skin with a lancet point or with an instrument made of three or four needles together. At the end of the second day a small reddish elevation (papule) is perceptible. By the end of the fifth day this has become a whitish blister (vesicle) with a central depression. On the eighth day it is distended with clear viscid fluid (lymph), the central depression being well marked and the vesicle surrounded by a circle of inflammation. This continues to enlarge and swell for 2 days longer, when it begins to subside and the vesicle to dry. About the fourteenth day only a dry brown scab remains, which falls off about a week later. The scar (cicatrix) which is left, is depressed and marked with little pits (foveated).

Vaccination instruments are best purified by being inserted for a second or two into the flame of a spirit or other lamp before each vaccination.

Re-vaccination is important because the protective effect of primary vaccination, especially if it has been imperfect and only performed at one or two spots, gradually becomes less. Young people should be re-vaccinated on reaching the age of puberty; and, whenever a case of small-pox occurs in a house, all residents in it should immediately be vaccinated. If a person be vaccinated two days after exposure to small-pox contagion, small-pox is entirely prevented, and if on the third day, it is "modified" and rendered less severe. Later than the third day vaccination has no protective power and develops concurrently with the small-pox. It is in such cases that mothers are inclined to state that the vaccinator has given her child small-pox.

Vaccination, even in the youngest infants, is practically without danger if properly performed. The lymph should be taken at the proper time from a healthy subject, and the person to be vaccinated ought not to be sick at the time. Erysipelas may attack the vaccinated spot, as it may attack a boil or a scratch if the subject be exposed to infection. For this reason "arm-to-arm" vaccination is being everywhere abandoned, and "calf-to-arm" vaccination has been introduced to guard against communication of human disease by careless vaccinators. The strain of vaccine lymph now in use in the Madras Presidency was first obtained by inoculating a calf with lymph from a human small-pox vesicle. After a few passages through calves the human small-pox virus loses its original characteristics and takes a milder form, and gives rise to the disease called vaccinia which is really a modified form of small-pox, though it retains the power of immunising the subject for a varying period against the primary disease. Great care is taken in selecting calves which are free from any disease and in maintaining them under the best conditions. The

abdomen of the calf is shaved, and lymph from another calf inoculated in long lines. When the vesicles mature, the lymph is removed and intimately mixed up with some preservative, such as glycerine or lanoline, and put up into capillaries or tubes for distribution to vaccinators.

Vaccination, in the countries where it is general, has had a remarkable effect upon the statistics of small-pox. We have seen that it has caused an enormous reduction of small-pox mortality; but it has also shifted the mortality of that disease from infancy to mature age. In England, 50 years ago, the deaths from small-pox under five years of age were three times as numerous as those above that age; these proportions have gradually changed as vaccination became more general, until at the present day they are reversed, the deaths above five years being three times as numerous as those under. Most of the deaths now * are above the age of 20. The evident explanation of this fact is that the influence of primary vaccination gradually diminishes; and the deaths from small-pox are now mainly confined to non-vaccinated persons and to persons who have been (often imperfectly) vaccinated in their infancy and have never been re-vaccinated. These statistics afford a strong argument in favour of revaccination.

We may also conclude from them that where the infantile mortality from small-pox is greater than the adult mortality from that disease, there is almost certainly defective vaccination. In 1884, in Bengal 72 per cent. and in Madras 64 per cent. of the deaths were of children under 12 years of age. In Madras City, during the epidemic of 1883–85, no less than

* This was in 1889. Since 1890, however, a reversion has been taking place and the infantile mortality rising, the reasons undoubtedly being neglect of vaccination and the permission of "Conscientious objections."

97 per cent. of the total deaths were in infants and children. This proves that infantile vaccination was much neglected, and that the adult population was largely protected by previous attacks of small-pox or by vaccination. After this epidemic, when vaccination was rendered compulsory in 1885, small-pox almost disappeared from Madras: but this disappearance was no doubt partly due to the protective effect of the preceding epidemic (and possibly to some concealment of cases).* The following table shows the fall in the small-pox mortality in British India during the past 40 years:—

—	1868–1877	1878–1887.	1888–1897.	1898–1907.
Deaths from small-pox ...	1,308,737	1,242,797	747,590	478,843
Death rate per 1,000,000 of population.	1318·5	1073·1	596·1	361·5

Plague.

In 1896 plague once again appeared in India in an epidemic form and has so far resisted all efforts to exterminate it. In 13 years the registered deaths from plague in India have amounted to 6,133,476. The causative bacillus enters the body either by inoculation through a skin wound, or by inhalation, or by the mouth. It leaves the body in the sputa in pneumonic cases, and to a less extent in the excreta. With the exception of the pneumonic cases, plague is not very readily communicated from man to man; infection seems generally to be derived from some common source outside the body. The contagium

* In a well-vaccinated community, the vaccination rate ought not to be much lower than the birth rate. The mean registered birth rate in the Madras Presidency is about 32 per 1,000; in reality it must be nearer 42. In 1908 the vaccination rate was 37·9 successful vaccinations per 1,000 of population.

can be carried about in infected clothes or goods. The disease does not very quickly establish itself in a fresh centre, but when it does so, it is extremely difficult to eradicate it. It is essentially a disease of locality. Rats and many other animals die from it, and may be the means of carrying it to uninfected places, either by land or by sea on board ships. Filth and overcrowding are prominent factors in determining its spread, and persons who live well and under sanitary conditions seem to run but little risk. The mortality varies from 60 per cent. to 90 per cent. but depends very largely on the hygienic surroundings.

Here the general conclusions of the Indian Plague Commission, published in 1908, may usefully be quoted *in extenso* :—

"1. Pneumonic plague is highly contagious. It is, however, rare (less than 3 per cent. of all cases) and plays a very small part in the general spread of the disease.

2. Bubonic plague in man is entirely dependant on the disease in the rat.

3. The infection is conveyed from rat to rat and from rat to man solely by means of the rat flea.

4. A case of bubonic plague in man is not in itself infectious.

5. A large majority of plague cases occur singly in houses. When more than one case occurs in a house, the attacks are generally nearly simultaneous.

6. Plague is usually conveyed from place to place by imported rat fleas, which are carried by people on their persons or in their baggage. The human agent himself not infrequently escapes infection.

7. Insanitary conditions have no relation to the occurrence of plague, except in so far that they favour infestation by rats.

8. The non-epidemic season is bridged over by acute plague in the rat, accompanied by a few cases amongst human beings."

It is evident that the Plague Commission commits itself wholly to the view that plague is primarily a disease of rats, and a chance infection of man; that the rat flea is the prime agent in the conveyance of plague from rat to man, and that without a sufficiency of susceptible rats and capable fleas the disease will not spread.

The flea is apparently a passive carrier of the plague bacillus, though the organism can multiply in the flea's stomach. When the infected flea bites a man, it does not inject living bacilli into the puncture, but as it sucks it is in the habit of depositing its fæces on the skin. The irritation caused by the bite leads the man to scratch the spot, and the living bacilli in the fæcal deposit can then be rubbed either into the puncture or into any abrasion of the skin pre-existing or produced by the man's nails in the act of scratching. It is held that this accounts for the immunity of children under one year of age who cannot scratch themselves.

A Russian observer has proved that the bug can carry the plague bacillus in a similar way.

When the mean temperature of the air is high, 85° F. and over, plague bacilli do not remain so long in the stomach of the flea as they do when the temperature is lower, and the flea does not then infect experimental animals so easily. This fact accords with the observation that plague epidemics tend to die down during the hot season.

Preventive measures, based on the acceptance of the rat flea theory, resolve themselves into those to be undertaken—

(*a*) before the importation of plague,
(*b*) after indigenous cases have occurred.

(*a*) *Before importation*—

Measures directed against rats :—

(1) Rats and their fleas are imported principally in grain sacks, so all grain sacks imported should be opened in a closed paved area, and any rats killed and immediately thrown into boiling water or a pulicide to destroy the fleas on them.

(2) Grain bags exported from an infected area should be first examined to prevent rats being sent with them as far as possible.

(3) All grain godowns should be made rat-proof as far as practicable, and the rats in their neighbourhood should be diligently trapped.

(4) Rats cannot live without food, so attention should be paid to the removal of garbage and the general cleanliness of dwellings and their surroundings.

(5) Disinfection of the clothes and belongings of persons arriving from infected places is not generally practicable, but infected fleas may be imported in this way, so a system of observation of such arrivals would aid in the early detection of a focus of infection started thereby.

(*b*) *After importation*, when an indigenous outbreak has been discovered—

(1) Vigorous trapping of rats should be undertaken in a circle round the infected area, so as to reduce the number of possible carriers.

(2) Inoculation should be pushed especially in the infected area.

(3) Removal of garbage, and house sanitation should be carefully attended to.

(4) If practicable the infected area should be evacuated.

(5) Cases of pneumonic plague should be isolated, and the rooms occupied by them disinfected to destroy the myriads of bacilli expectorated.

When plague has been imported into a village, the best way to stop the epidemic is to evacuate the village at once, and accommodate the inhabitants in temporary huts some distance away.

All articles removed should be disinfected to destroy fleas, and after evacuation it is useful to clean up the village to remove all food for rats.

From what has been said, it is evident that disinfection of plague-infected houses has a limited value. Rats live in holes and the fleas mostly live on the rats, and disinfectants and pulicides, however liberally applied, can merely kill fleas that happen to be on the floors or in clothing. Still, performed with intelligence, disinfection may do some good and can do no harm.

The principles outlined above must be also applied to prevent the importation of plague by vessels from infected ports.

Enteric or Typhoid Fever

is a specific disease due to infection with the typhoid bacillus. It generally enters the body in water contaminated with human excreta, but may, like cholera and perhaps dysentery, be carried about by flies. Dried fæcal matter containing the bacillus may also be blown about by the wind and thus spread disease. It is of world-wide occurrence, and in India affects both Europeans and Natives. The contagium leaves the body both in the fæces and in the urine, and it has been shown to be present in the urine sometimes for many weeks after convalescence. The disease is not air-borne in the sense that small-pox is, so mere proximity with a patient is not dangerous. Similar precautions must be taken in disinfecting the excreta as in cholera. General preventive measures consist in securing pure water and good drainage, and cleanliness of surroundings. Milk is considered to be one of the most frequent mediums for the conveyance of typhoid. Pure milk

cannot contain the bacilli, but milk is frequently adulterated with polluted water.

Persons likely to be exposed to infection may be protected by a prophylactic inoculation.

It has been shown that occasionally persons who have been in contact with cases of enteric fever may harbour the specific bacillus in their intestines and excrete it in their fæces and urine for a short time, without presenting any symptoms. Likewise a certain number of persons who have recovered from an attack pass the bacilli in their urine for months afterwards. These chronic carriers may be a danger to the community.

Dysentery and Diarrhœa.

In all tropical countries the mortality from bowel diseases is very high and from diseases of the lungs comparatively low, the opposite of what occurs in cold climates. Under the term "dysentery" is still included a variety of diseased conditions due to causes which are not thoroughly known. Amongst these is one due to the invasion of the intestine by a bacillus, and another to the presence of an amœba. Dysentery at times is epidemic and is then readily communicable by food or water contaminated by fæcal matter. It is particularly fatal in times of famine when people eat much indigestible material and drink any water obtainable. General improvement of sanitation in a town leads to a diminution in the mortality from bowel diseases, and persons who are careful about the purity of their food and drink run little risk of an attack, though accidents may happen to all. Dysentery prevails at the same times and in the same places as malaria, but the two diseases are quite distinct.

Infantile Diarrhœa.

In all countries a large proportion of the deaths amongst young children is caused by diarrhœa.

Excluding those in which the principal factor is improper feeding, it appears certain that many cases are due to definite microbic infection. Diarrhœa frequently becomes epidemic during the autumn months—August, September and October—and prevails in England chiefly amongst bottle-fed infants, whose food is obviously exposed to contamination which breast-fed infants are likely to escape. It has been noticed that dry, dusty summers are followed by a much more extensive outbreak of diarrhœa than wet summers, and it also appears that those towns, which are most attentive to the cleanliness of their streets and wash the surfaces of their roadways most freely, suffer least from infantile diarrhœa. If, as is probable, the microbes which give rise to this diarrhœa flourish chiefly in the dirt and organic matter which collects in the streets, it is clear that they can be spread about most readily in dry, windy weather, and that rain which washes the roadways will carry them away. Similarly, in India it happens that, if August and September are wet months, the mortality from diarrhœa is greatly lessened. Though in India nearly all infants are breast-fed they often get other food as well, and the mortality from diarrhœa is in some years exceedingly high.

Prevention.—Well-paved or well-metalled roads, free watering of the surface in dry weather and careful removal of all rubbish and excreta, will go a long way towards keeping a locality free from epidemic infantile diarrhœa.

Relapsing Fever

appears only when the surroundings are insanitary, and overcrowding exists together with destitution and semi-starvation. The exciting cause is an active spirillum which is found in the blood during the paroxysms.

The disease appears to be particularly common in Bombay, but cases have not been reported in Madras. The case mortality varies from 2—15 per cent. The disease in some parts of the world appears to be spread by means of a tick, in others by the bed bug, and there may be other unrecognised carriers. Preventive measures lie in the cleanliness of domestic furniture and surroundings, and in the destruction of bugs and ticks in houses.

Measles and Chicken-pox

are common enough diseases in India. The only interest of the latter lies in the difficulty occasionally experienced in distinguishing it from mild and modified small-pox. If there be any doubt, the more serious disease should be assumed. The mortality from chicken-pox is *nil*. Measles on the other hand is responsible for a good many deaths amongst children. It is readily communicable through the air and by contact. Sufferers should be isolated at home, as it is not often practicable to admit them into a hospital, and steps should be taken to prevent them from attending school until the period of infectivity has passed.

Tuberculosis

exists all over the world and accounts for the deaths of nearly one-seventh of mankind. Tubercular disease of the lungs, or phthisis, is a common disease in Madras and in many other parts of India. It is also common amongst cattle in Europe, but not so much in India: in the Madras Presidency, for instance, it is exceedingly rare to find a tuberculous animal in a slaughter-house. The exciting cause is the tubercle bacillus which finds entrance by inhalation. It leaves the body in immense numbers in the sputum of the infected person, and, being able to

survive desiccation, it may be found in the dust of the rooms he inhabits and spits about in.

Phthisis is encouraged by dampness of soil, overcrowding, defective ventilation, sedentary occupations, and bodily debility from any cause; a predisposition towards it is inherited.

Prevention resolves itself into living in dry, light, well-ventilated and clean houses, attendance to personal hygiene, and avoidance of contact with phthisical persons.

Stringent regulations are now in force in certain countries with the object of putting a stop to spitting in public places. Every person suffering from phthisis should be made aware that he is spreading the contagium by indiscriminate expectoration. Phthisical sputa should be received into a vessel containing disinfectant and afterwards burnt.

Syphilis

resembles tuberculosis in its slow progress and its lengthened duration. It has long been assumed to be of microbic nature from its clinical history and natural characters, but the causative agent, a spirochæte, has only recently been discovered. So far as is known, it is communicable only by inoculation. Inoculation may take place accidentally in various ways; for instance surgeons are not rarely inoculated through scratches on their fingers, but it is usually communicated by sexual intercourse with uncleanly prostitutes. Though syphilis is not often directly fatal, it often causes much suffering and prolonged ill-health and degenerations of organs, which may conduce to death from other causes. It is also transmitted frequently to the offspring of syphilitic parents (congenital syphilis). The disease is common all over India, very prevalent in some places, but accurate statistics of it are wanting.

Prevention of syphilis.—This disease, as well as gonorrhœa and local contagious sores, could be greatly mitigated, if not completely stamped out, by organised inspection and the isolation and treatment of diseased prostitutes. Those of the lowest class require most attention, since they are the most active agents in its propagation. Such inspection and treatment was carried out for many years at large military stations in England and in India with great benefit to the troops, to the civil population, and to the prostitutes themselves; but in 1883 some misguided, but very clamorous, persons in England raised an outcry against the *Contagious Diseases Act* which has resulted in its—let it be hoped only temporary—abrogation.

Prostitution cannot be suppressed by the State so long as sexual passion and present social conditions remain. It is regulated by law in many European States with obvious benefit. So far from promiscuous immorality being encouraged thereby, the reverse is the case; for many young girls who wish to change their mode of life are enabled to do so, and it is probable that domestic morality is increased.

Leprosy

is due to a bacillus which slowly multiplies in the tissues. Owing to the long incubation period and very chronic nature of the malady, it is very difficult to come to definite conclusions as to its communicability. Most authorities, however, are agreed that it is communicable, and particular stress is laid by Sticker on the infectivity of the nasal discharges. The disease is found in most parts of India and does not seem to be much, if at all, on the increase.

Salt-fish is credited by Hutchinson with an important part in its causation. Marriages of lepers should be discouraged. The only practicable

preventive measure is the segregation of all lepers in hospitals or asylums, or in leper colonies or villages.

Voluntary leper asylums have been opened in many towns in India, but compulsion is not resorted to. Lepers should not be permitted to follow any occupation connected with the sale of food or drink, or which brings them into intimate contact with other people.

Other Communicable Diseases

which are either unknown, or else rarely seen in India, are not touched upon in this manual, nor are those diseases mentioned in which preventive measures cannot as yet be undertaken by reason of our want of knowledge as to their causation.

CHAPTER XVI.

DISINFECTION.

The object of disinfection is to destroy the contagium of disease, the pathogenic microbes finding their way out of the body of a patient and lurking in clothes, furniture, rooms and dirty places generally. We have to find means of killing not only microbes but their more highly resistant spores, at the same time doing as little damage to personal property as possible. A careful distinction must be drawn between three classes of substances; viz., deodorants, antiseptics and disinfectants.

Deodorants merely oxidise or absorb the gaseous products of decomposition and thereby destroy foul odours. Charcoal, earth, ashes, numerous patent powders, and a variety of chemicals are examples of this class. They have no very perceptible action on the microbes themselves.

Antiseptics put a stop to the further growth of bacteria and thus prevent decomposition, but they do not necessarily destroy the vitality of the organisms. Various chemicals have this power.

Disinfectants proper destroy completely both microbes and their spores. Though the rays of the sun and plenty of fresh air have a powerful influence in this direction, still they cannot be absolutely depended on, and are only of use in supplementing the action of true disinfectants.

Disinfection may be performed either by physical or chemical agency. In the former case heat is employed, and in the latter a variety of chemicals.

Theory of Disinfection.—Disinfection by chemicals must be regarded as an ordinary chemical reaction between the disinfecting substance on the one hand and the protein molecules of the bacteria on the other. The rate at which the process progresses is related to the number of bacteria to be dealt with and at any moment is proportional to the concentration of the surviving bacteria. The reason that all the bacteria are not killed off simultaneously is probably owing to temporary energy changes in the molecules of the bacterial protoplasm, which recur at intervals, so that the bacteria are not at every instant of time in a fit state for chemical union with the disinfectant. Besides these temporary variations there are also permanent differences in the resistance of individual bacilli due to causes such as age. Similarly there is no constant temperature at which bacteria are destroyed by heat; destruction begins at a certain point and proceeds more and more rapidly as the temperature rises. For example a suspension of bacteria might be all destroyed in 2 hours at 47° C., in 18 minutes at 51° C. and in 2½ minutes at 55° C. Their destruction is due to the coagulation of their protoplasm by the heat. Further experimentation is required to determine the germicidal value of substances such as perchloride of mercury when simply dissolved in water and when dissolved with the aid of other chemicals, such as ammonium chloride. The disinfecting power of perchloride of mercury is dependent on the presence of free mercury ions in the solution and, if the number of these is reduced by the formation of complex salts, derived from the chemicals added to aid the solution of the comparatively insoluble disinfectant, it is probable that the final result is a fluid of less germicidal value, even though, actually, a greater quantity of the disinfectant has been dissolved.

Disinfection by Heat.

Heat may be applied in the dry form or the moist form.

The effect on the colour and the texture of the articles to be disinfected must be considered. Woollen goods will not stand as high a temperature as those composed of cotton or linen.

Most fabrics will stand a temperature of 110° C. without permanent injury. Cotton, linen and silk will bear 110° C. dry heat for 4 hours and 122° C. moist heat for ½ hour. Cotton is scorched at 140° C. Scorching occurs sooner with woollen materials. 126° C. moist heat applied for 30 minutes turns white woollen blankets yellowish and diminishes the tensile strength of the hairs, as well as causing great shrinkage. Clothes which are soiled with albuminous discharges, *e.g.*, blood and excreta, should be soaked in cold water before being disinfected by heat, otherwise coagulation of the albumen will occur and a permanent stain result.

Books and leather goods are spoiled by moist heat and to a lesser extent by dry heat. They should be disinfected by formaldehyde gas or sulphur dioxide.

Dry heat penetrates very slowly, and to destroy spores the temperature has to be maintained for a length of time at a height which ruins nearly all fabrics. It is not much employed for this reason.

Moist heat may be applied directly by boiling water or indirectly in the form of steam.

(1) *Boiling* for half-an-hour will disinfect any article for practical purposes, but the operator must assure himself that the articles are actually penetrated by the boiling water. A mass of clothing thrust into a cauldron of boiling water at once lowers the temperature, and boiling ceases for some time. The water penetrates with difficulty into the

centres of tightly tied up articles. Woollen blankets are spoiled by boiling. The process is expensive and can only be employed occasionally on a small scale.

(2) *Steam.*—The great thing aimed at is to secure penetration of bulky articles. Hot air does not readily penetrate, and the temperature inside a roll of blankets, even after some hours' exposure to hot air, may not reach a sufficient height to kill bacilli. Steam, on the contrary, does penetrate. Articles may be disinfected or sterilised by exposing them to the action of *current steam* (100° C.) at the pressure of the air for three hours. A current is necessary to expel the air from the interstices. Exposure for one hour to steam at 100° C. will destroy all pathogenic bacilli and their spores. The penetrating power of moist heat in the form of steam is due to the condensation of the steam as it advances into a cold object, and the formation of a partial vacuum which is at once filled by more steam from behind, and so on. As the steam condenses, it parts with its latent heat, and raises the temperature of the matter in the vicinity to a high degree.

To hasten the process of disinfection, steam under pressure in special machines is employed, as a higher temperature than that of boiling water can thus be obtained. 120° C. applied for 20 minutes is sufficient to sterilise any article. Steam, whether generated at atmospheric pressure, a pressure of 10 lbs. or 30 lbs. to the square inch, is saturated and will at once condense on an object cooler than itself. Saturated steam may, however, be further heated without increasing the pressure. It is then called superheated steam and acts like a gas, and will not condense until it has lost the extra heat which has been imparted to it. As the penetrating power of steam depends on its condensation, superheated steam is not so good as saturated steam.

A steam disinfector consists of an outer jacket containing steam under pressure, and an inner chamber into which the articles to be disinfected are put. Air is first exhausted from the chamber and then steam is passed in till the required temperature (120° C.) and pressure are reached. These are maintained for 20 minutes, and then the steam is allowed to escape from the chamber, and hot air is drawn in once or twice to dry the contents before they are removed. Cotton, linen and silk fabrics bear steam disinfection well, woollen goods not so well. Leather is ruined.

Disinfection by Chemical Agency

may be performed either by gases or liquids.

Chemical disinfectants—(1) *Gases.*—Chlorine, sulphur dioxide, nitrous acid, and formaldehyde all find their uses in the disinfection of rooms, particularly in the case of air-borne diseases such as scarlatina, diphtheria, influenza, measles and small-pox. A long time is expended in the process and great care has to be taken in sealing up all apertures to prevent the escape of the gas. Neither the structure of Indian houses nor the staff at command lend themselves to the wide adoption of disinfection by gases, so this method may for practical purposes be ignored. It is scarcely necessary to point out the futility of burning sulphur and tar in the streets, or even in the courtyards of houses, during the prevalence of cholera and other epidemics.

(2) *Liquids.*—Perchloride of mercury or corrosive sublimate in the strength of 1 part by weight in 1,000 parts by weight of water has been very largely used in plague epidemics in India. Its disadvantages are that it corrodes metals and is poisonous. For practical purposes it will be found

convenient to keep a stock of a concentrated solution and to dilute this when required.

Perchloride of mercury	10 lbs.
Ammonium chloride	$2\frac{1}{2}$,,
Water	1 gallon.

Dissolve with gentle heat, stirring in an earthenware pot and add commercial hydrochloric acid, 2 gallons.

This makes a concentrated solution of 1 in 3 which should be stored in glass stoppered bottles or stoneware jars. It is customary to colour the diluted solution with a little red ink powder or aniline blue to avoid the risk of its being mistaken for pure water.

Carbolic acid is soluble in water (1 in 8 or 10). A 1 in 20, or 5 per cent., solution is necessary to destroy bacteria and spores. It dissolves more easily in hot water than in cold. Alkalies and soft soap assist in its solution. Commercial carbolic and many of the patent disinfecting fluids consist chiefly of cresols, and contain only a small proportion of phenol. This, however, does not affect their bactericidal power, but tar oils which have no bactericidal power are sometimes freely mixed in.

The volume of tar oils in a disinfecting liquid may be ascertained by shaking it up with twice its volume of 9 per cent. soda, and allowing the mixture to stand in a graduated cylinder. The alkali dissolves the acid disinfectants, and the heavy oils sink to the bottom of the column and the light oils form a layer at the top, when their relative volumes can be easily calculated.

Numerous disinfectants derived from coal tar have of recent years been placed before the public. They consist mainly of the higher phenol derivatives brought into emulsion by means of resins and fatty acids, and have the advantages of being easy to use, cheap, non-toxic and more powerful than

carbolic acid. Some of them are *Cofectant*, *Cyllin*, *Izal* and *Kerol*. The working strength of these fluids is about 1 in 400.

Chloride of lime.—A solution containing at least ½ per cent. available chlorine should be employed. It is a powerful oxidising agent, but it corrodes metals and may exhaust itself on organic matter without injuring bacilli.

There are numerous other disinfectants of varying efficiency on the market, and numerous exceedingly active ones which find employment mostly in laboratory and hospital work, as they are too expensive for use on a large scale.

Potassium permanganate, being non-poisonous, is employed for water-supplies and cooking vessels.

Slaked lime if quite fresh absorbs sulphuretted hydrogen and organic vapours. It corrodes metals. It cannot be classed as a disinfectant, but is a useful application for dirty walls. None of the patent powders, including carbolic powders, are anything but deodorants. Their use, indeed, is often to be deprecated, since people are inclined to believe that they are of real value when scattered round latrines and drains. At the best they merely mask foul odours.

Practical Disinfection.

The first thing to be certain of is the efficiency of the disinfectant in use. A number of articles may be bought, the bactericidal power of which is very low and which are of little worth as germ destroyers. Now that fairly reliable laboratory methods have been devised of comparing the bactericidal power of liquids, there is no excuse for a public body laying in a stock of any substance that is not of guaranteed power. It must be remembered that the influence of various factors on practical

disinfection have not yet been accurately determined, so that the laboratory determination of the efficiency of a fluid is not necessarily a measure of its comparative efficiency in practice. Disturbing factors in practice are the presence of albuminous and other foreign matter, the nature of the material to be disinfected, and the character of the water available for diluting the disinfecting fluid.

A hard water may interfere considerably with the properties of the disinfectant, so the softest and purest to be found should always be used. A disinfectant works better at a high temperature than at a low one, and the length of time of contact is a factor of the utmost importance which has to be thought of in connection with the concentration. It appears that a disinfecting substance is more potent when in a state of emulsion than when in solution.

Disinfecting officers, before starting work, must bear in mind what they are setting out to perform, where the infective matter is likely to lie: otherwise large quantities of fluid may be distributed and great expense incurred and inconvenience caused without a proportionate amount of good resulting. For instance, in a cholera epidemic, nothing is gained by burning the roofs of huts, or saturating them with liquid disinfectant, for the causative agent of the disease is not to be found in the roof.

In the present state of sanitary administration in India, in the absence of a compulsory general notification of infectious diseases, only a few diseases come under the notice of the sanitary officials in which the disinfection of houses is required. These are plague, small-pox, cholera and occasionally measles.

Our remarks on this subject may be conveniently sub-divided as they relate to disinfection (1) of

inhabited rooms, (2) of vacant rooms, (3) of persons, (4) of clothing, etc., (5) of effete materials from the sick, (6) of dead bodies, (7) of sewers, cesspits, latrines, etc., (8) of food and drink. In this country all elaborate apparatus in the way of sprays and patent pumps for distributing liquid disinfectants had better be avoided. Coolies only break them and do quite efficient work with the help of nothing beyond a few buckets and tubs, wooden scoops for throwing the solutions on the walls, mops and country brushes. A great point in disinfecting a house is to burn the vast amount of foul and useless rags and rubbish that is often discovered. Removal of tiles and thatch not only admits fresh air and sunlight, but assists in the rapid drying up of soaked floors.

In the disinfection of inhabited rooms, as of other places, the great importance of cleanliness and free ventilation and admission of light, as adjuvants, need scarcely be further alluded to. If the room is actually occupied by a sick person suffering from any readily communicable disease, attention must mainly be directed towards preventing the spread of infection. If the disease be of a kind easily communicable through air, special care must be taken to isolate the sufferer as previously explained. Emanations from his skin may be disinfected and be prevented from passing into the air by some local application, such as carbolized oil. The floor and walls of the room should be washed with the disinfectant issued, taking care to reach all corners and crevices and not neglecting articles of furniture. After rooms have been vacated, disinfection of all parts should be most thorough.

Disinfection of clothing is very important. The infection of diseases, such as small-pox and other eruptive fevers, clings to clothing, especially woollen articles, for a long time, and is thus often

transported and disseminated. Sanitary authorities should see to the proper purification of infected clothing and prevent its being sent to washermen or laundries. Happily the disinfection of clothing is a simple matter. It suffices to boil it in water for half-an-hour. Immersion in the usual disinfectant may be employed instead of boiling. Articles which would be damaged by wetting or boiling may be disinfected by dry heat, in places where a suitable disinfecting chamber is provided. Thick, bulky articles such as mattresses, rezais and blankets are best disinfected in a steam disinfector. If this be not possible they can be soaked in perchloride solution and spread out in the sun to dry.

Discharges from the sick, soiled rags, etc., should be received in vessels containing a sufficiency of some strong disinfectant, such as crude carbolic acid, ferric chloride, or mercuric chloride solution. In the absence of these, dried earth or sawdust may be used as an absorbent for them, this being, as soon as possible, cremated. Soiled straw of bedding, old worthless clothes, etc., should be wrapped in a sheet or bag soaked in disinfecting solution, and be taken out and burnt. The disinfection of all discharges from the bowels, and of clothes or bedding soiled with them, is particularly important in cholera, enteric fever, and dysentery, but it should on no account be neglected in small-pox and similar diseases.

The body of a person who has died of a readily communicable disease should be completely enveloped in a sheet wetted with strong disinfectant solution, and be cremated or buried with the least possible delay. If there be any discharges flowing, dried earth or chaff mixed with some disinfectant should be placed under the body.

Well made and well kept latrines should not, as a rule, be in need of disinfection. During epidemics,

and when it is known that they have been used by persons suffering from readily communicable diseases, it may be useful to employ disinfectants in them. It is occasionally necessary to disinfect cess-pits and damp, slimy, and muddy places. Sulphuric acid, 1 in 250, or 3 ounces to 4 gallons of fluid, is probably the best substance to use in these circumstances.

For sluicing a paka built house with disinfectant, the following strength may be employed: perchloride of mercury 1 in 1,000; cyllin, izal or kerol 1 in 300 or 1 in 400; carbolic acid 1 in 40; and the same strengths will do for soaking clothing or bedding, provided that the articles are really soaked. When it is necessary to disinfect the excreta in cases of typhoid, cholera, diarrhœa or dysentery, a much higher concentration is required, for much of the disinfectant is wasted by contact with the organic matter. Carbolic 1 in 20, cyllin, izal or kerol 1 in 100, perchloride of mercury 1 in 180, must be used in such a case in sufficient quantity and well mixed up with the discharges After half-an-hour has been allowed for the disinfectant to act, the mixture may be burnt, buried or poured into a sewer.

If sulphur dioxide gas is used for room disinfection, all the contents of the rooms must previously be as freely exposed as possible, as the gas has little power of penetration.

3 lb. of sulphur at least should be burnt for every 1,000 cubic feet of space, and the room should be left for not less than 6 hours with all apertures closely pasted up.

If formaldehyde gas is used, 30 tablets of paraform should be vapourised in a special apparatus such as the Alformant lamp, for each 1,000 cubic feet of space, and the room must be sealed up for 6 hours. Gaseous disinfection is very uncertain in

its action and, as remarked before, is unsuited to Indian houses.

It is certain that some, and probable that other, infectious diseases may be communicated in food or drink. Recent and thorough cooking is a certain disinfectant and the best safeguard against such communications. At all times, but more especially during epidemics, it is a wise precaution to cook or boil all articles of food or drink which are not entirely above suspicion, and not to keep them after cooking in any place where they may be exposed to infection by man or by domestic animals or insects or dust.

Disinfection of Schools.—A great deal of sickness and disease amongst children and students can be averted by the systematic, daily disinfection of all school rooms and lecture halls. After the day's work is over all the benches, desks and other fittings, walls and floor should be thoroughly washed over with a disinfecting fluid, such as cyllin, 1 in 400. Teachers will find, if they pursue this plan for a year, that their average daily attendance will be materially higher owing to fewer absences from avoidable sickness.

Disinfecting Stations.

When disinfection is carried out on a large scale, it is best performed by a steam apparatus. Infected clothing must be removed from the infected houses before disinfection of the house itself is begun, in a covered van, and taken to the station where it is disinfected, and returned in another clean van. In India there is seldom need for a disinfecting station in a town, partly because distances make it inconvenient, and partly because the amount of infected clothing and bedding to be disinfected is too small to make its removal worth while: it is easier to do it on the premises with liquids. Sometimes a steam

disinfector on wheels which can be dragged from place to place is useful.

At sea-ports and at health camps or railway lines where there may be a great deal of disinfection of passengers' clothing to be performed, a stationary steam apparatus is a necessity.

Disinfection of Ships is required when they arrive in a port with cases of infectious disease on board. All bedding, curtains, carpets, linen, etc., are taken to the steam apparatus on shore. The cabins and living parts of the ships are then disinfected by some liquid which is most conveniently applied by means of a hose. The hold and its contained cargo can only be disinfected by pumping in chlorine, sulphur dioxide or formaldehyde gas and battening down the hatches. Rats and insects are killed in this way, but the penetration of the gases is incomplete, and disinfection is, in consequence, not thorough. Cargo moreover may be injured.

An empty hold may be disinfected by any of the liquid disinfectants applied with a hose, first saponifying the oil and grease in the bilge water with caustic alkali.

CHAPTER XVII.

VITAL STATISTICS.

Preliminary Considerations.

Statistics are the numerical expression of collected facts and their relations. Vital statistics may be defined as the statistical method applied to the investigation of facts relating to human life.

In order to get a clear understanding of the meaning of masses of facts, which are too large numerically to be grasped by the mind and sorted and assessed at their proper value, to determine the relations of such facts to each other, and to make rational inductions concerning the underlying causes and laws, it is necessary to express them as precisely as possible by figures. A judgment based on the experiences of a life-time will be correct only as far as the temperament of the observer permits: from the same experiences an optimist will arrive at a conclusion widely differing from that of a pessimist, but if their common experiences can be reduced to a simple table of figures, less room for a difference can exist.

All sanitary officials must be acquainted with the methods of collecting and arranging the data or facts from which vital statistics are compiled, and it cannot be too clearly understood that the value of the results depends on the absence of error in the original facts tabulated. Primary numbers or simple statistical quantities, must contain all the units of a like kind which are to be enumerated. The errors which are likely to exist in such numbers are due to (1) omission of correct units, or (2) inclusion of incorrect units. For instance in a return of

deaths from cholera in a population (1) some cholera deaths may be omitted owing to improper statement of cause or concealment of death, or (2) some deaths from dysentery and diarrhœa or other diseases may be included; the result being in either case an incorrect *primary number* expressing the deaths from cholera. Clear definition of the distinctive characters of the group to be represented, and accurate collection of all units belonging to that group, and of no others, are necessary in order to obtain a correct primary number.

Statistical facts may be expressed either (1) by simple statement of one or more primary numbers, (2) by the *ratio* of two or more numbers, or (3) by *averages* (*means*) deduced from two or more numbers.

Ratios, or proportions, are useful in showing the relative numerical importance or size of two primary numbers which are to be compared together, and in reducing them to a uniform scale, so that they may be compared with other proportional numbers. For example, if the mortality in three towns were as follows,

Towns.	Population.	Deaths.
(1)	4,680	117
(2)	33,700	1,078
(3)	18,375	496

the actual numbers would not convey a clear idea of the relation of deaths to population in any one of the towns, or of the relative mortality of the three towns. But if we state that out of every 1,000 persons in each town the following number died:—

(1)	25
(2)	32
(3)	27

the ratios are at once evident

The most usual, and generally the best, method for comparing two numbers is to state one (usually the larger) as 100, and the other as a *percentage* of this.

Another method of stating a ratio, which is sometimes useful (for it appears to convey a more definite and vivid impression to minds which are unused to deal with figures), is to reduce the smaller number to unity and state it as "one in so many." For instance, the mortality of the three towns in the above example may be stated as 1 in 40, 1 in 31 and 1 in 37, respectively. This method possesses the disadvantage that the changing number becomes greater or less *inversely* as the facts it represents increase or diminish in number. A percentage increases or diminishes *directly*.

When several proportional figures have to be compared together, the percentage method is preferable. If the two numbers differ greatly in magnitude, it is convenient, in order to avoid fractions, to state the larger one as 1,000, or some multiple of 1,000,* the smaller one being proportionately increased.

Fallacies of Ratios.—The value of a ratio as an average statement of fact, or as an indication of future probability, depends mainly upon the number of units upon which it is based: the larger the number, the more trustworthy is the ratio. For instance, if in a household of 10 persons two deaths happened in one year, the mortality of that particular

* The calculation of a percentage is an operation in "simple proportion." For example, in the first of the towns mentioned above, 117 has to be calculated as percentage on 4,680 and $\frac{117 \times 100}{4,680} = 2{\cdot}5$ which is the required percentage. To reduce the smaller number to unity and the larger number proportionately, divide both by the smaller number. In the same example $\frac{117}{117} = 1$ and $\frac{4,680}{117} = 40$.

household was at the rate of 200 per 1,000, or 1 in 5 per annum; but it would be manifestly absurd to accept this as representing the mortality of the town in which the household was situate, or as an indication of the probable future mortality in similar households. But if we have 3,000 deaths in a population of 100,000 persons, the death-rate of 30 per 1,000 may be accepted as closely representing the true death-rate of a population of which the 100,000 is a fair sample, and as an indication of what their future death-rate will be under similar circumstances. In stating a ratio, therefore, it is always important that the numbers upon which the ratio is calculated should be made known. In most cases, conclusions derived from less than 100 units must be regarded as unreliable and only to be accepted provisionally, subject to confirmation. Those founded on 1,000 units are generally very close to the truth; and 10,000 unist may be regarded as affording practical accuracy for most purposes.*

Ratios should not be founded upon two variable factors: one of the factors must be fixed and the other variable. It is a common error, for instance, to calculate infantile deaths as a percentage of total deaths, the correct method being to calculate them on the infantile population; and similarly, deaths from one disease should not be stated as a proportion to deaths from all diseases. Methods of this kind should at all events not be resorted to except for special purposes, and keeping in view the errors they involve. In the case of variable populations corrections can be made for differences of increase, diminution, or age-constitution, so that their rates may be strictly comparable. In Indian statistics

* The degree of accuracy increases not directly, but as the square root of the number of observations.

all ratios reckoned on population are more or less incorrect, because they are calculated on the *uncorrected* populations of the previous census.

Means.—The mean or average of a series of numbers indicating similar facts is a single number which is representative of the series or group.*

A mean not only represents a group of numbers by a single number, but it may afford a more or less trustworthy indication of future probabilities with regard to facts of the same nature. Generally speaking, the larger the number of members upon which the mean is calculated, and the less they individually diverge from the mean, the more valuable is that mean, whether as a representative statement of the facts indicated by those members or as a forecast of probabilities.

To judge of the value of a mean, the extremes, that is the lowest and highest item represented by the mean, should always be stated. The extent of divergence, + or — from the mean, of the members may be expressed in percentages of the mean, and a mean may be usefully supplemented by a figure, showing what proportion of the members of the series differs from it by a relatively small quantity. The *mean error* may be calculated by (1) finding the mean of all the members which are above the general mean of the whole series and subtracting the general mean from it, the + mean error being thus obtained; (2) finding the mean of all the members which are below the general mean, the — mean error being thus obtained. The two numbers

* The *arithmetic mean* is the true mean for ordinary statistical inquiries. It is obtained by dividing the sum of the series by the number of members in the series. For example, the mean of 56, 32 and 41 is $\frac{56 + 32 + 41}{3} = 43$. In certain cases, however, the arithmetic mean is not correct; thus when the members of a series differ in "weight" (relative importance), the true or *geometric* mean must be obtained otherwise.

added together and divided by two give the mean error.

Fallacies of average.—Supposing that each of the numbers upon which an average is computed be in itself reliable, and that those numbers be sufficiently numerous to yield a good average, yet the average may be a comparatively worthless and misleading expression, because the difference in the numbers is great. It may be that not only the extremes are great, but that none of the numbers is near the average. For simplicity we will take the average of two numbers; say that average is 50; the numbers on which it is founded may be very divergent, as 1 and 99, nearer, as 25 and 75, very close to the average, as 49 and 51, or even identical with it. Hence the advisability of stating extremes, and if they diverge much from the average, of adding a statement showing the degree in which the numbers approximate to the average. The units composing an average may aptly be compared to the mark of rifle-bullets on a target: in the most valuable and representative average they will all be close to the centre, in a less valuable average they will be more or less scattered, extremes being perhaps very far from the centre, and in the least valuable average they will be nearest to the margin of the target. We will now turn to some common errors in practical statistics connected with averages.

The average of ratios is often computed in a manner which is extremely erroneous, the average being reckoned on the mere ratio-numbers, forgetting that such numbers may differ largely in weight. The relative weights, for instance, of death-rates are in proportion to the relative numbers of the populations to which they refer.

If the populations are equal, the mean of their death-rates is the true mean death-rate of the whole; and, if the death-rates are equal, the same death-rate is true for the whole. But if the populations

are unequal and have different death-rates, the simplest method of calculating their combined death-rate is to reckon the rate on the sum of the populations and the sum of the deaths. For example, suppose three populations as follows :—

Population.	Deaths.	Death-rate.
24,780	510	20·6
30,615	649	21·2
101,912	4,159	40·8

The combined or average death-rate of the whole population is not the arithmetical average of the death-rates of its parts $\frac{20·6 + 21·2 + 40·8}{3} = 27·5$ but $\frac{5,318 \times 1,000}{156,370} = 34$.

A correct reckoning of *average strength* is important for obtaining true rates in the case of shifting and variable populations, such as those of troops, jails, schools, and works where the number of men varies. The average strength is the sum of the numbers present each day divided by 365, the number of days in the year.

In calculating annual rates when the population was present only a part of the year, the same rule must be observed ; for instance, if the place was occupied for only 160 days, the sum of the daily population for these days must still be divided by 365 to give the average *annual* strength, and the rates (taking the sum of the local events such as deaths) must be calculated on this to obtain annual rates. Rates should on no account be calculated on "total population" (*i.e.*, number present at the beginning of the year + admissions during the year). "A total population of 365 might mean 365 persons in residence throughout the year, or 365 entering on the last day of the year, or 1 entering daily."

Objects of Statistical Enquiries.—The reasons for collecting statistics on matters concerning society are that exact information may be available to enable a right judgment to be formed of the influence of passing events such as scarcity, famine, war, commercial depression, epidemic disease, emigration and immigration on the prosperity of the community; and that it may be clear whether the sanitary and other enactments in force are tending towards good or evil. The aim of all sanitary measures is to improve the conditions of life so as to prolong the lives of a greater number of the population into the working period. Every baby born is equivalent to so much capital to the State, since it is potentially capable of so much work. This capital only becomes available after the individual has reached an age when he can look after himself, work, and contribute to the support of others. If his life be cut short before he has reached maturity the food, money, time and attention that have been expended on his bringing up and education are lost for ever to the community; the youth having died cannot make repayment by his work. If his life end before he has reached middle age, he may have just repaid the sum invested in him by the community, but may not have contributed much to the general stock of wealth in his turn. If he live till old age compels him to cease from labour, he will have contributed more to the community than was expended in rearing him, but if he live long, while old and unable to work, he again becomes a drain on the common resources. It is obvious then that every death in infancy is a direct loss to the community, and that a still greater loss is incurred by every death in early manhood before life's work has well begun. It follows that every man who does no work, either mental or manual, is a dead loss to the community. This includes all persons who live idly on wealth accumulated by

their fathers, and all beggars, and those who live on charity, doing nothing in return.

Arrangement of Statistics.—The method of arranging statistical facts is only second in importance to their correct compilation. The facts when intended for general use must be presented in a readily comprehensible form, because ill-educated persons, and even well-educated persons who are unacquainted with statistical methods, will fail to draw correct inferences from figures which they understand imperfectly or improperly. Statistical facts may be stated (1) numerically, (2) graphically, and (3) numerico-graphically. The first method consists of simple statements of numbers, such as sums, ratios or averages.

The graphic method consists of the representation of statistical results by lines, spaces, colours, shading, etc. Thus lines of various length or spaces of various size may be drawn to scale in the ratios of numbers representing facts which it is intended to compare together, and such lines or spaces may be coloured to distinguish them more vividly. The geographical distribution of certain facts may be shown by maps variously coloured or shaded.*

The numerico-graphical method of arrangement is most frequently employed and most convenient for general purposes. It includes the use of tables, curves, or lines, combined with numbers, etc.

Fallacies of Comparison.—False inferences are very frequently made by comparing numbers which are not comparable, or which can properly become so only after corrections have been made. A few of

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* Race or family characters of feature which are not readily amenable to numerical expression, may be averaged by superposing feeble photographic images of individuals so as to produce a single picture. *(F. Galton.)*

the commonest errors are here noticed. Errors of comparison may arise in connection with primary numbers, ratios, or averages.

Primary numbers expressing certain variable facts in relation to other variable facts are sometimes wrongly quoted as though they were true ratios. It is obviously incorrect to compare totals (such as total deaths) affecting populations of different magnitudes; but it is also, though not so obviously, incorrect to compare totals affecting the same population at different periods. Thus an annually increasing number of deaths in a place does not at all warrant the inference that the place is becoming more unhealthy, nor does an annually diminishing number of deaths warrant the inference that a place is becoming more healthy; in the first case the population may be increasing, and in the second case it may be diminishing in a more rapid proportion than the deaths, and its age-constitution may have changed. The use of primary numbers to express ratios is rarely justifiable; but they may often be usefully quoted to show the reliability of ratios calculated on them, or to impress persons unaccustomed to statistical inquiries with the magnitude of certain aggregate facts.

With regard to ratios, errors are very often made by comparing the rates of differently constituted populations as to age and sex, or differing as to race, habits, occupation and wealth. *All* causes of variation should be kept in view when ratios are compared with regard to particular cases of variation. Ratios calculated on insufficient numbers or for very short periods must never be accepted as true, especially for comparative purposes.*

* The incorrectness of ratios on population as calculated in all Indian vital statistics is elsewhere alluded to. No allowance is made for increase or decrease, but they are reckoned on the population of the last census. The error thus tends to increase every year after a census and to render such numbers more

The more representative an average is, that is, the closer its constituent members approach it, the more valuable it is for comparative as well as for other purposes. It is unsafe to compare averages of which the "mean error" is large or from which the "extremes" are very divergent.

POPULATION.

A correct knowledge of the composition of the population concerned is the first essential for statistical purposes. Exact information can only be obtained directly by a census.

Few populations, however, are stationary; it therefore becomes necessary to form estimates of population during the periods between censuses. This can be done accurately if complete returns of the number of births and deaths and of immigrants and emigrants are available; but in most places—practically all places in India—such returns are far too imperfect for the purpose.

Another method which gives generally correct results (and is employed by the Registrar-General of England) is therefore to be preferred. It is assumed that the rate of increase (or decrease) in a population remains constant, and the ascertained rate of increase during the period between two censuses is taken as the rate of increase during the next intercensal period. Since the increments to population also increase, the calculation is evidently one of "compound interest."

The mean population of the year (*i.e.*, population calculated to the middle of the year) should be taken for reckoning annual rates, etc.

It may be observed that in Indian vital statistics, all rates are calculated upon the *uncorrected* population according to the last census. A needless error, which increases every year after a census, is thus added to their admitted faultiness.

The census of 1881 showed the population of the Madras Presidency to have decreased by 1·5 per cent. owing to the great famine of 1876–77. In 1891 it had increased by 15·5 per cent., a higher rate than the average, due to a rebound after the famine. The 1901 census showed an increase of 7·2 per cent. to have taken place, which is probably about the normal rate.

Parts of the Bombay Presidency which had suffered severely from plague showed a decrease at the 1901 census.

The average annual rate of increase per 1,000 of population in the Madras Presidency as a whole is, therefore, between 7 and 8, and this may be used as rough basis for estimates of increase during the current inter-censal period.

CENSUS.

The first census of India was taken in 1851, and thereafter quinquennial censuses were taken until 1871, when a decennial interval was adopted. Decennial censuses have been taken in England since 1801. A shorter interval would be advantageous, because estimates of population, made many years after a census, are often erroneous to a considerable extent, and because it would conduce to greater accuracy of each census, the people being more accustomed to the inquiry and a larger number of experienced persons being available as enumerators.

Besides a mere enumeration of the population, much valuable information as to its composition and its social condition is elicited by a well-planned census; and successive censuses exhibit the changes in a population. The following are the most important inquiries which are made: age, sex, occupation, conjugal condition, infirmities, number of inhabited houses, density of population. Of less

importance from a sanitary point of view are education, religion, race, caste,* language, birth-place.

Age.—One of the most essential requirements in vital statistics is to know the age-composition of populations. Without any intentional misrepresentations two kinds of error have been found to prevail in age statements: the age of infants is apt to be overstated, infants under one year being returned as one year old, under two years as two years old, etc., the infantile population thus tending to appear less numerous than it really is, and adults are apt to have their ages given in round numbers as 30, 40, 50, etc. Clear instructions and care on the part of enumerators ought to reduce the first error; the second is to a great extent obviated by adopting age groups of 25–35, 35–45, etc., instead of 20–30, 30–40, etc.

The age-constitution of a population depends upon the birth-rate, death-rate, emigration and immigration. Emigrants are generally young adults; emigration, therefore, generally exerts an unfavourable and immigration a favourable influence on the age-constitution of the population. When the birth-rate of a population is continuously higher than its death-rate, the population not only increases, but its age-constitution is so affected that it possesses a larger proportion of individuals at the lower ages than a population which is not increasing, or is increasing at a slower rate.

Populations of different age-constitution cannot be properly compared with one another unless due allowance be made for the difference. For instance —to take an extreme case, but one not unknown—

* With regard to this subject the Report of the Madras Census of 1871 by W. R. Cornish, contains the most complete account which has been written.

it is absurd to compare, without correction for age-distribution, the mortality among a body of young people, such as school children, or of adults, such as workmen or troops, with the mortality of the general population. In comparing urban with rural populations, or even town populations with one another, differences of age-constitution should be taken into account if they be at all considerable. A knowledge of age-constitution is also very important in estimating the value of hygienic measures and for various other sanitary statistical purposes. In English statistics it is generally stated in quinquennial groups from 0 to 25, and decennial groups from 25 to 75, above 75 forming a single group.

The age-distribution of the population of the Madras Presidency at the census of 1901 is here shown per 1,000 persons living :—

All ages.	0–4	5–9	10–14	15 19	20 24	25-34	35-44	45–54	55 and over.
1,000	136	142	122	79	78	155	123	82	73

NOTE.—These figures are of doubtful accuracy.

This may be compared with the following table which gives the age-distribution of 1,000 persons in England and Wales in 1891 :—

All ages.	0-4	5-9	10–14	15 19	20 24	25-34	35-44	45–54	55 and over.
1,000	122	118	113	101	88	146	112	86	114

The economic value of a population largely depends upon its age-constitution : other things being equal in two populations, it is manifest that the one which possesses the larger proportion of individuals at working ages (15 to 50) has material advantage over the other.

Sex.—The sex-constitution of a population is important in particular cases when it differs much from the normal. The marriage, birth, and death-rates are influenced by it. In the Madras Presidency nearly 103 males are born for every 100 females born *; but here as in every other country, the mortality of males at the earlier (under 5 years) and later ages (over 35) exceeds that of females, so that the population normally contains more females than males in the proportion of 102 to 100.†

Mixed populations differ so little from one another in sex-constitution that no correction need usually be made on this account when comparing their death-rates, etc.

Occupation has very considerable influence upon health. As a rule, town and sedentary occupations have a deteriorating influence when compared with country and active occupations. Agriculture is the pursuit of the great majority of people in India.

The following table ‡ gives a comparison of the class-composition of the Madras and English populations:—

Class.	Madras.	England.
Professional	4	7
Domestic	1	3
Commercial	3	11
Agricultural	67	20
Industrial	19	49
Labourers, etc.	6	10
Total ...	100	100

* The mean corrected birth-rates according to Mr. G. Stokes, being for males 43·11 and for females 41·90. The experience of the Madras Lying-in Hospital, however, (1873 82) in 13,544 births, gives the proportion of male to 100 female births as before the famine 115, during the famine 98, and after the famine 111.

† According to 1881 census, also in 1901.

‡ Madras Census Report, 1881.

The above classes should be largely sub-divided. To ascertain the effect of occupation on health, the mortality from different causes, as well as the total mortality, should be known. The mortality at different groups of ages should also be ascertained. In comparing the death-rates of persons engaged in particular trades or callings, it must not be forgotten that persons are so employed during working ages, and that the age and sex-composition of the different groups is likely to differ largely, and needs to be taken into account.

Conjugal Condition.—According to the Madras Census Report of 1881, of the total population 45·5 per cent. were single, 42 per cent. married, and 2·5 per cent. widowed.

In Madras 173 per 10,000 men under 15 years of age were married, in England only 11 per 10,000 men under 20. In Madras 1,132 per 10,000 women under 15 were married, in England only 67 per 10,000 women under 20. In Madras only 5·3 per cent. of women over 15 were single, while in England 25·8 per cent. of women over 20 were single. These figures show that the difference between the conjugal condition of the people in India and that of the people of England (and other European countries) consists in the comparatively very early marriage of the former.* In England the average age at marriage (1895) is for men 28·4 and for women 26·2 years; and one-fifth of the people who attain a marriageable age never marry. In England the lowest, poorest and the least educated classes marry earliest, and the socially highest and best-educated, latest, the average age at marriage in the professional and independent class being 31·22 years for men and

* Some of the evil results of unrestrained early marriage have been already noticed. The ancient Greeks excelled in their admiration for, and cultivation of, physical perfection, and it is noticeable that Aristotle considered that men should marry at the age of 37 and women at 18, and Plato, that men should be from 25 to 55 and women from 20–40.

26·4 years for women; but, even in the lowest classes, marriage is influenced by prudential considerations, and the marriages become fewer and later when prosperity diminishes. In India no prudential motives have, even in the educated classes, outweighed the power of custom, which enforces marriage at the earliest possible age.

The marriage-rate and age at marriage are most important as influencing the birth-rate of a population, the fecundity of early marriages being greater than that of later ones.* Earlier marriage must tend to increase population, even if the number of children to each marriage be not increased, for the intervals between generations will be diminished.

In a population where late marriage and a considerable amount of celibacy prevail, natural selection has much more important play in improving the race, than in a population where all women marry at the earliest possible age and celibacy is practically unknown. In the former population many weakly persons die between the age of puberty and the usual marriage-age—persons who would have married in the latter population; and selection has considerable scope among those who survive, many remaining unmarried.

Infirmities.—The Census Report of 1901 shows that in the Madras Presidency out of every million of the population there were—

In	Insane.	Deaf-mutes.	Blind.	Lepers.
1871	446	1,313	1,946	441
1881	325	536	1,597	466
1891	215	760	1,022	353
1901	188	644	891	351

* Dr. M. Duncan found the average fecundity of women marrying at 15–19 years of age was 9·12, and it progressively diminished as ages advanced, being 4·6 for those marrying at 30–34 years. $\frac{\text{Births}}{\text{Marriages}}$ = mean fecundity per marriage.

These figures are not very reliable, as friends are reluctant to publish such defects and enumerators cannot be expected to distinguish leprosy without fail.

The number of inhabited houses affords some indication of the extent of overcrowding in houses and a means of making future estimates of population. It is found that the mean number of persons per inhabited house remains fairly constant in the same population; enumeration of inhabited houses, therefore, affords a check on estimates of population at inter-censal periods, and it affords the best method—short of a census—for estimating the number of a population which has been much affected by migration.*

Overcrowding in houses is no doubt a great cause of disease and death; but it must be borne in mind that the greatest overcrowding occurs among the most indigent, who live, in other respects also, under the most insanitary conditions.

Density of population for general or country populations is usually stated as number of persons to each square mile, and for towns as number of persons to each acre. It may also be reckoned by making area the variable factor and calculating the number of acres or square yards to each person.†

The number of persons per square mile in the Madras Presidency according to the census of—

1871	was	227
1881	,,	221 (Famine, 1876—1877).
1891	,,	253
1901	,,	270

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* In 1901 the average number of persons per occupied house in Madras City was 9. The average for the whole Presidency was 5.

† $\frac{\text{Population}}{\text{Area}}$ = mean population per unit of area, and $\frac{\text{Area}}{\text{Population}}$ = mean area to each person.

In 1901 the extremes were Tanjore 561 and Kurnool 115. In 1881 the average in Bengal was 457, North-West Provinces 416, Burma 43, England 447.

In country districts the density of population has usually little or no effect on health or mortality. In India, indeed, increased density in country districts may conduce to an improvement of public health, by causing the removal of unhealthy scrub and the cultivation of waste lands.

It is in towns that density of population has particularly obnoxious effects. Other things being equal, the denser the population of a town, the higher its death-rate, and, conversely, the more the inhabitants are spread out, the less the mortality. Density in itself is not necessarily a cause of mortality: it is the conditions of life which are almost inseparable from overcrowding, which lead to ill-health.

In towns many causes of disease exist from which villages are comparatively free. The poor and the dissolute are attracted to towns in search of food, or money, or dissipation. Temptations to the adoption of unhealthy practices are greater. Every nuisance and every case of communicable disease becomes a greater danger as the population is larger. Cleansing is more difficult, and, if it is not well performed, pollution of soil and air are more extensive. If there be no public water-supply from without, the contamination of drinking water is greater. Different classes are apt to congregate in different localities; and thus the poorer quarters of large towns teem with a concentration of vice, misery, filth and disease. To all these and other evils are dwellers in towns exposed; and we need not wonder that they should generally suffer from sickness and mortality to a larger extent than do the inhabitants of villages.

The inhabitants of towns, however, have certain advantages which are denied to those who live in crowded villages. They can afford to carry out well arranged schemes for the removal of refuse and excreta, and the supply of a pure drinking water, which are usually beyond the means of villages; and if overcrowding and its accompanying evils can be avoided, they may live in healthier surroundings than are usually found in villages.

If poverty tends to concentrate itself in towns, so does wealth tend to accumulate in them. If large communities breed dirt, so do they afford means for its removal; if they harbour pestilence, so can they combine to suppress it. They can command skilled advice and the means for acting upon it. They can bring pure water from a distance, or build works for its purification; they can construct and maintain well made sewers, drains, slaughter-houses, latrines, markets, hospitals for infectious diseases, cremation or burial places, and sewage-farms, and can manage a public system of cleansing and lighting. They can make and enforce regulations as to the sanitary construction and maintenance of houses, the sale of wholesome food, the isolation of infectious diseases, and many other matters connected with the public health and well-being.

Large towns may thus do much towards sanitation, which is beyond the knowledge or the means of individuals or of small communities; and, with vigorous administration and the assistance of loans for large public works, Indian municipal towns ought to make rapid strides in reducing their present unhealthiness.

Registration of Births and Deaths.

An accurate registration of births and deaths, with subsidiary particulars, is as necessary to the

sanitary statist as an accurate knowledge of population obtained by census.

In India generally such registration has hitherto been extremely imperfect and unreliable. Recent legislative enactments, if enforced, will no doubt improve it in municipal towns; but it will be long before district registration can become satisfactory. In the city of Madras, registration is compulsory under a penalty of Rs. 20 for default (section 379, Madras City Municipal Act, 1904). In the District Municipalities Act, 1884, though provision is made for registration, there is no penal clause; but a penalty may be provided for in bye-laws under this Act. In the Local Boards Act, 1884, the subject of registration is not mentioned.*

So long as registration of births and deaths is imperfect, it will be impossible to form exact judgments as to the sanitary needs of communities, and as to improvements in their condition.

The most necessary particulars required in registering births are date, sex, nationality or caste, profession of father; and in registering deaths, date, age, sex, cause of death, profession, residence.†

Other items which ought to be included in birth registration are:—

(1) the numerical order of each birth;

(2) the age of the mother at each birth, so that in course of time accurate information might be available as to the number of children borne by women at different ages, and the total number in the course of their lives.

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* District registration is performed by village headmen. It ought to be regarded as a very important part of their duties; and, if severe notice were always taken of its neglect, district returns would be much better than they are. When the registered death-rates are below 30, and birth-rates much below 40, defective registration may be suspected.

† *Vide* forms prescribed in Schedules L. and M. of Madras Municipal Act.

Still-born children should not properly be included in either the birth or death registers, but a separate register of them should be kept.

The *cause of death* is a very important particular and one which it is often difficult to obtain with accuracy, even in countries where registration is otherwise good. The reasons for this are difficulties in the classification and nomenclature of diseases and faulty diagnosis. When causes of death cannot be ascertained by registrars, they should be marked "not known."

Births.—The actual registered birth-rate in the Madras Presidency averages 30 per 1,000, but there is good reason for thinking that in reality it is well over 40 per 1,000. In Madras City where birth registration is fairly good, though by no means perfect, the birth-rate is generally near 40 per 1,000. The annual birth-rate of a community is calculated according to the subjoined formula:

$$\frac{\text{Number of births in one year} \times 1{,}000}{\text{Population}}$$

Weekly birth-rates are calculated thus—

$$\frac{\text{Number of births during one week} \times 52{\cdot}17\ (\text{number of weeks in 1 year}) \times 1{,}000}{\text{Population}}$$

In this case the meaning of the figure obtained is that, if the same number of births which occurred in that week continued to occur every week throughout the year, the rate would be so and so.

Similarly, calculations can be made for monthly and quarterly periods.

In comparing the birth-rates of two populations, their age and sex composition must be taken into account if they differ much. An approximate correction for differences in age and sex composition may be made by calculating the birth-rates on the

female population at child-bearing ages instead of on the general population.

Causes which increase the birth-rate are early marriage, favourable age-constitution of population (a large proportion of the women being of child-bearing ages), favourable sex-constitution of population (the normal proportion, or, in polygamous societies, an excess of women), and abundance of food.

Early marriage increases the birth-rate in three ways: by producing a larger number of children per marriage, by diminishing the intervals between generations, and by producing a favourable age-constitution of population.

Birth-rate and age-constitution exert a mutual influence upon each other. A continuously high birth-rate produces a population containing an excessive proportion of youthful and young adult members: and such a population is naturally productive of a high birth-rate, especially in India, on account of the early and general marriage of girls. A favourable age-constitution produced by other causes, such as a migration of young adults to a town, or a high death-rate, tends similarly to increase the birth-rate.

Deaths.—The registered death-rate for the whole of the Madras Presidency during 1908 was 26·2 per 1,000. In municipalities and towns the rate was 32·3 per 1,000, and in districts excluding towns 25·3 per 1,000. Owing to defective registration these numbers are almost certainly short of the true figures.

The annual death-rate of a place is calculated in a precisely similar way to the birth-rate.

$$\frac{\text{Number of Deaths in one year} \times 1{,}000.}{\text{Population,}}$$

Large fluctuations in death-rates for short periods may be due to climatic causes, epidemics, or diseases which have a marked seasonal prevalence. Short period rates should be reckoned only for large populations, else they are unreliable owing to an insufficient number of data. Weekly or monthly mortality statements are of great value for indicating sanitary changes which may not be evident and for estimating those which are evident. "The deaths serve the purpose of a self-registering inspection" (Farr). The general death-rate of a population is the most commonly employed test of its sanitary condition, and it is generally a reliable test.

The sensitiveness of Indian death-rates to sanitary conditions is remarkable, and their fluctuations are greater than those of European populations. This sensitiveness may be attributed to several causes: (1) the low age-constitution of the population, which naturally favours a low death-rate; (2) the high birth-rate, infantile mortality forming a large proportion of general mortality and being notoriously sensitive to sanitary conditions; (3) the early marriage of all girls, which causes the population to breed up to its means of subsistence and renders it easily and extensively affected by want; (4) the high death-rate, which is more easily and largely affected by favourable conditions than a low death-rate, and conduces to a low mean age of population. Large fluctuations are commonly due to epidemics of cholera or small-pox, to outbursts of malaria and times of scarcity.

Special death-rates applied to separate causes of death and to separate sections of the population are of the greatest use in sanitary investigations. They show the effect of diseases, or of age, sex, occupation, locality, etc., on mortality, and by revealing the causes or particular incidence of high death-rates, may enable defects to be pointed out and the

efficacy of remedies to be estimated. A few of the more important special death-rates are noticed below.

The death-rate at different ages is a very important sub-division of the general death-rate. The presence of insanitary conditions, or of diseases which affect life at different periods, are thus made evident. Since the age-constitution of different populations may vary considerably, it is important that age-mortality should always be reckoned on the population at different age-groups, and not (as it is frequently and wrongly) as a percentage of total deaths; and the variations of the latter constitute a further reason for reckoning the deaths at particular ages on the population at those ages. The infantile (under 1 year) death-rate is best reckoned on the births of the year.

To show the varying mortality in different age-groups the following tables are inserted:—

Mean annual rate of mortality in England and Wales per 1,000 of each sex, 1891--1895.

——	Males.	Females.	——	Males.	Females.
All ages ...	19·8	17·7	35–44	12·2	10·3
Under 5 ...	62·1	52·0	45–54	19·8	15·3
5–9 ...	4·5	4·5	55–64	36·3	29·8
10–14 ...	2·5	2·7	65–74	71·9	62·8
15–19 ...	4·0	4·0	75–84	149·9	136·1
20–24 ...	5·3	4·9	85 and upwards.	290·6	263·8
25–34 ...	7·2	6·7			

Rate of mortality in Madras City per 1,000 of each sex in 1900.

——	Males.	Females.	——	Males.	Females.
All ages ...	46·9	45·5	20–39	21·0	21·3
Under 5 ...	171·7	151·7	40–59	38·2	30·7
5–9 ...	20·3	19·8	60 and over ...	124·1	138·5
10–19 ...	13·6	16·7			

Neither birth-rates nor death-rates can fairly be compared in different towns or communities, unless corrections be made for the age and sex distribution of the populations.

Men must die and their age is limited; so it is impossible for the death-rate to drop below a certain figure even in the healthiest and best managed town. A death-rate of 10 per 1,000 means either that every child born lives to 100, or that if some die before attaining that age, others must greatly exceed it. If the span of life remains at about its present length, in a town with an average age and sex distribution we cannot expect the death-rate to touch a much lower ratio than 15 per 1,000. In the tropics where conditions of life are not so favourable as in temperate climates, it is probable that a death-rate of 20 per 1,000 will never be improved upon.

Infantile mortality is the ratio of deaths under one year to 1,000 births. It should not be calculated either on the general or infantile population. Other things being equal, the infantile mortality is regarded as a most reliable indication of the sanitary condition of a town or district. In 78 English towns taken together, the infantile mortality in 1895 was 160. In 1899 the infantile mortality in Calcutta was 366 per 1,000 births, in Bombay 786, and in Madras 272.

The above tables show (1) that mortality differs very much at different ages, being much below the general rate between the ages of 5 and 45, and much above it under 5 and over 55; (2) that the mortality of the sexes shows sensible differences, the general death-rate of males being considerably higher than that of females, the male mortality being in excess under 5 and over 20 in England, and under 10 and over 40 in Madras. Consequently

the death-rate of a population will be lowered by an increased proportion of persons aged 5—45 and of females, and conversely.

The excessive male mortality under 5 occurs almost entirely in infants, and is attributable to the larger size and more difficult birth of males. The higher female mortality from 10 to 20 may be partly attributable to diseases of puberty, and it is undoubtedly increased by too early marriage; it is much higher proportionately, as well as actually, in Madras than in England.

The excessive and increasing male mortality over 20 in England is apparently due to the greater hardship of men's lives.

Correction of death-rates for age and sex is manifestly necessary for correct comparison of the death-rates of different populations. In most mixed populations the proportion of sexes is so nearly equal that it is unnecessary to make any correction for sex; but in special cases it must be made. In comparing the death-rate of the population of the same place at different periods, correction for age also is rarely required, because, in the absence of violent disturbing causes (as famine or migration), the age-constitution is not liable to rapid change. In mixed populations differences of age-constitution rarely occasion a difference exceeding 3 in their death-rates per 1,000. When the difference is much larger than this, correction for age is never likely to reverse the position, though it will state it more accurately.* It is in the case of special death-rates, such as those of troops or schools, that corrections for age and sex are most necessary, often essential, for comparative purposes.

* For further information on all subjects connected with vital statistics Dr. A. Newsholme's book on this subject may be consulted.

The effect of public institutions, such as hospitals, jails, or lunatic asylums in towns, may be to increase perceptibly the death-rate. Persons in such institutions who do not belong to the place may properly be excluded from the general statistics of the population. Places resorted to by pilgrims or other strangers may similarly have their death-rates affected, if the deaths of such persons are included. On the other hand, the presence of a considerable number of young students, or troops, or the influx of young adults into a town may lower its mortality. These, however, are taken into account in giving the age-distribution of the population.

The relation of birth-rates to death-rates is very important. Owing to the almost constant coincidence of high birth-rates and high death-rates, they have been by many authorities regarded as cause and effect. Their true relationship was expounded by Dr. Farr, who pointed out that a continuously high birth-rate naturally tends to produce an age-distribution of population which is favourable to a low death-rate, that is to increase the proportion of persons living at the lower ages (5—45) whose death-rate is naturally low.

The first effect of an increased birth-rate (*i.e.*, for the first five years) must, however, be to increase the death-rate, owing to the increase of the infantile population among whom mortality is high.

But it cannot be doubted that a continuously high birth-rate in a population must cause indirectly a continuously high death-rate, when, owing to any cause such as improvidence, idleness, ignorance or density of population, means of subsistence do not or cannot increase with commensurate rapidity. In other words the "misery check" of Malthus must come into play. Ill-nourished mothers beget starveling children and suckle them with milk which is

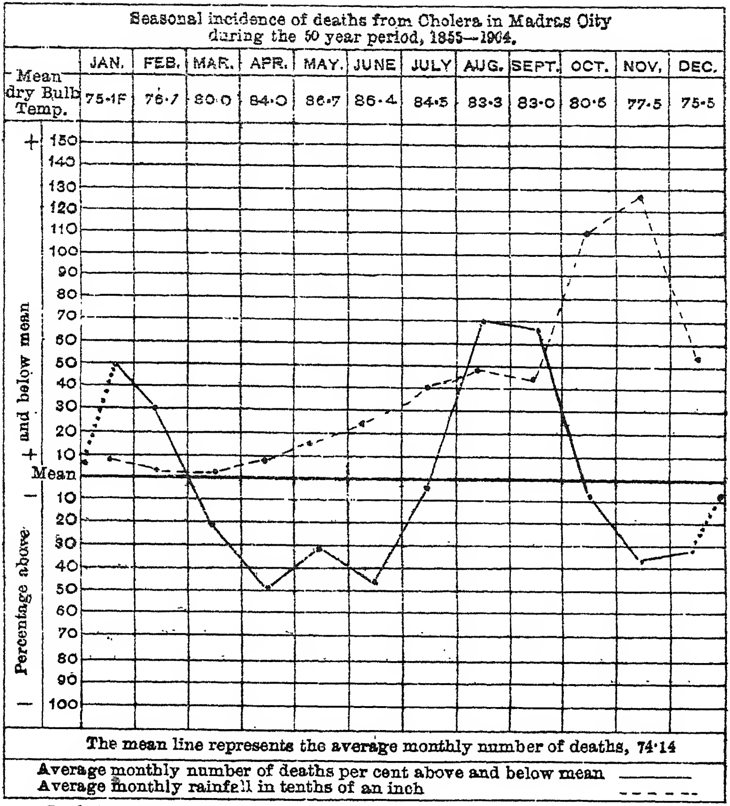
deficient in quality * and quantity ; the infant mortality is thus easily increased, and poverty, overcrowding, and deficient food foster other insanitary conditions, and conduce to a high death-rate at other ages. In these ways a high birth-rate practically does cause a high death-rate, although, at the same time, it may produce an age-distribution of population favourable to a low death-rate.

In India for statistics of the general population, the following causes of death alone are distinguished :—

1. Cholera.
2. Small-pox.
3. Plague.
4. Fevers.
5. Dysentery and diarrhœa.
6. Respiratory diseases.
7. Injuries { Suicide. Wounds and accidents. Snakes and wild beasts.
8. All other causes.

Medical returns from hospitals, jails, and troops give a classification of deaths according to the *Nomenclature of Diseases* compiled by a committee of the Royal College of Physicians, London. This was founded upon, but differs in some respects from, the Registrar-General's method of classification. Classification of diseases is not, however, a question to be discussed here ; what is of more immediate importance to us is the nomenclature of diseases ; and in registering causes of death, it is important (1) to use only the names contained in the official nomenclature, and (2) to state the remote, rather than the proximate, cause ; for instance, death from pneumonia during an attack of measles should be returned as death from measles. A complete and reliable registration of causes of death is impossible, unless all the deceased were attended or examined by competent medical men who can certify the causes.

* Analyses of *famine-milk* were made by the late Mr. W. Hamilton and show *great* loss in this respect. Cornish : *Sanitary and Medical Aspects of Famine*. Appendix I, Report, Sanitary Commissioner, Madras, 1877.



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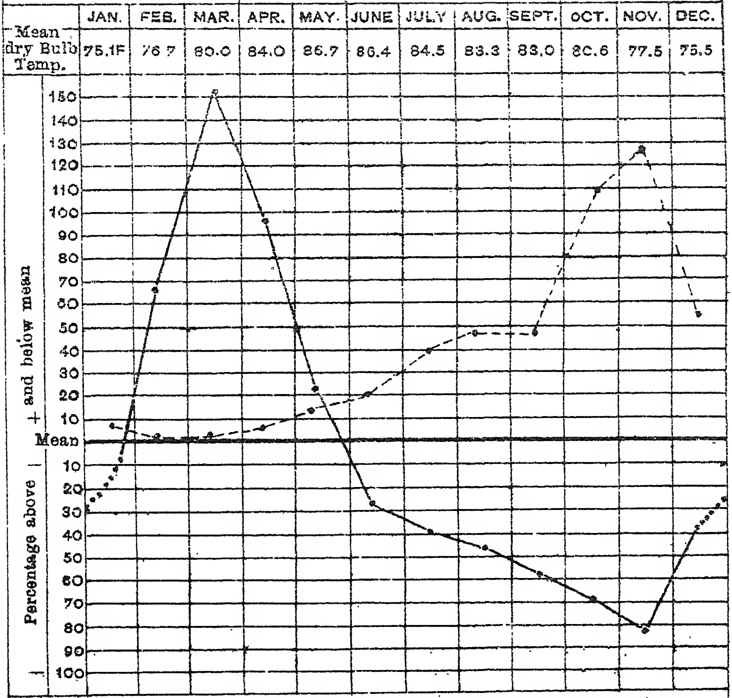
Seasonal incidence of deaths from Small-pox in Madras City during the 50 year period, 1855—1904.



The mean line represents the average monthly number of deaths, 46·8

Average monthly number of deaths above and below mean ————

Average monthly rainfall in tenths of an inch - - - - - - -

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The time is approaching when such a registration may be attempted in some of the more advanced towns: at present it would be impossible. Some diseases occur only at certain periods of life, or prevail especially at certain periods. The mean age at death from such diseases is of medical interest, and the prevalence of such diseases in connection with the age-constitution of a population, is of sanitary and statistical importance.

Deaths according to locality form an obviously useful distribution of the general death-rate, and may often serve as an indication or as a measure of local causes of unhealthiness. Local death-rates in districts of large towns may be employed for this purpose. The geographical distribution of endemic diseases and the course of epidemics may be traced with accuracy by local death-rates; and useful knowledge regarding their causation and prevention may thus be gathered.

Deaths according to occupation should be recorded by registration.* Occupational mortality has been alluded to already under the head of *Census*. In comparing the death-rates of different populations, the possible influence of differences in their occupations should be borne in mind.

Deaths according to season give many useful indications, especially when deaths from special causes are so recorded.

The charts opposite exhibit the seasonal mortality from small-pox and cholera in Madras City during the 50 years 1855—1904.

Sickness.—Registration of sickness has hitherto been found impossible for the general population anywhere. It has only been effected in the case of public services, companies, societies, and institutions.

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* A column for profession is contained in the form prescribed by the City of Madras Municipal Act.

From statistics of sickness thus obtained, more or less trustworthy estimates of sickness among the general population may be framed when we possess good mortality statistics. Dr. Farr estimated that in England for every annual death which occurs, two persons are constantly sick; in other words, for one death there are two years of severe sickness.

The sanitary officer would be in a much better position to deal with preventible diseases, if he could know of the occurrence of every case and not the fatal ones only. Moreover, from the epidemiological point of view much information of value could be collected if all the non-fatal cases were reported. Epidemics differ very much in fatality, and, from the economical point of view, the number of persons incapacitated by sickness is really of greater importance to the prosperity of the community than the number of deaths.

Duration of Life.

Although the duration of an individual life is proverbially uncertain, yet the average duration of life in a large community of men is subject to very little fluctuation.

This is evident from the following figures which are also held to indicate the influence of improved sanitation, and better conditions of life generally, on the national prosperity. In England the expectation of life at birth of males

Between	1838 and 1854	was	39·91	years;
,,	1871 and 1880	,,	41·35	,,
,,	1881 and 1890	,,	43·66	,,
,,	1891 and 1900	,,	44·13	,,

so that during the period of 62 years between 1838 and 1900, the average national life increased in length 4·22 years, and this, if an addition to the working years of a man's life, means a vast increase of wealth to the State. On the other hand, if it

merely means that the improved conditions have resulted in saving the lives of infants and unhealthy individuals for a few years, who would otherwise have died, it is obvious that the improvement has not yet gone far enough, that the State has only succeeded in burdening itself with a number of useless lives which are not sufficiently prolonged to reach into the period of working years. That the latter view is the correct one is supported by the fact that the expectation of life for adults over 26 years of age is now actually less than formerly.

Life tables are the only exact means for ascertaining the duration of life and the probabilities of death at birth or at subsequent ages. They are founded upon the number and ages of the living, and the number and ages of those who die in a population; and represent "a generation of individuals passing through time."

A *life-table population* (which is of course hypothetical) consists of a number of individuals born at the same moment, whose course through life is traced, the number dying in each year being recorded. Its statistics, therefore, are free from the errors attending those of changing populations.* Owing to the differences of male and female mortality, separate life-tables for each sex are commonly prepared.

The principal indications obtainable from a life-table are: (1) age or past life-time; (2) annual mortality at each age; (3) probability of living one year from each age; (4) number born and living at each age; (5) mean population in each year of age, (6) years which the persons at each age will live, (7) mean after life-time at each age.

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* For methods of construction of life-tables Dr. Farr's Vital Statistics

If a correct life-table of a community can be prepared, data exist from which the aggregate future life-time of the estimated population according to their age-groups can be calculated for any particular year or period. This is called the *life capital* of that community, in other words it is the average of the total number of years which the members of that community may be expected to live, and it may be used as a measure of the sanitary progress, or the reverse, of the community. The life capital of the population of England and Wales is nearly 39 years.

The mean duration of life which is the most reliable test of sanitary state, is identical with the mean after life-time from a birth, or expectation of life. When no life-table is available the mean duration of life may be obtained approximately from the birth and death rates by the use of Farr's formula $\left(\frac{2}{3} \times \frac{1}{d}\right) + \left(\frac{1}{3} \times \frac{1}{b}\right)$,—*b* being the birth rate, and *d* the death rate per *unit* of population. For instance the corrected Madras birth rate (as given by Mr. Stokes) is 42·4 and the death rate 33·7; therefore $\left(\frac{2}{3} \times \frac{1}{\cdot 0337}\right) + \left(\frac{1}{3} \times \frac{1}{\cdot 0424}\right) = 27{\cdot}6$ years, which is the approximate mean duration of life in a Madras population. In England the mean duration of life is 43 years.

CHAPTER XVIII.

SANITARY LAW.

As pointed out in the last chapter, accurate information concerning the causes which influence the health of a community, can only be arrived at by the collection and study of vital statistics, and it is not until governing bodies have incontrovertible facts laid before them, and can be fully persuaded that the measures proposed are based on sound principles, that they can undertake to regulate the conduct of the public by sanitary laws and enactments. Individual members of the public generally display remarkable selfishness in their disregard both of the convenience and of the health of their neighbours, particularly when the expenditure of any money is involved; and it is to control selfish actions which would be detrimental to the health of the community, as well as to guide the ignorant, that sanitary legislation is necessary.

The opposition to proposed sanitary measures and to any interference with the liberties of the public, which is frequently heard, is generally due to the fact that the benefits of control are not immediately obvious; and the majority of the people in all countries are not far seeing enough to understand what is to be gained.

In India sanitary legislation must of necessity be greatly in advance of popular ideas of education, and sometimes opposed to old-rooted prejudices and time-honoured habits. Unfortunately those who possess a modern education are not always those who have most influence with the illiterate masses, and

the difficulties of the sanitary legislator, and, even more, the difficulties of the sanitary administrator, are immensely increased thereby.

To ensure the success of a sanitary law the people must in some measure be educated up to it, so that they shall have an idea of its purport. The great value of *permissive legislation* is that it thus paves the way for more stringent and effective laws.

Recent Indian legislation has conferred very extensive powers upon local bodies. Until these bodies have shown themselves capable of wielding such powers efficiently, and the people more fully recognise their value, there can be little need for more extensive powers. Lacking, as we do and must do for a long time to come, a sufficient number of properly-educated sanitary administrators, efforts should be directed to their training, and to the sanitary education of the people under them, as the best means of rendering present laws effective. Heretofore these laws have been, as a rule, notoriously ineffective.

The main purposes of sanitary legislation are—

(1) to protect individuals and communities from injury to health by their neighbours' faults (including, necessarily, restriction of their own malpractices);

(2) to make provision for the joint execution of large sanitary enterprises.

Sanitary Administration.

In England the Local Government Board is the supreme sanitary authority. It consists of a President, Secretaries, clerks, legal adviser, and a large staff of inspectors for the administration of the poor-law, auditors of local accounts, engineering and medical inspectors.

The duties of the Local Government Board are to supervise registration of births, deaths and

marriages, public health generally and the prevention of disease, administration of the poor-law, drainage and water schemes, vaccination, public improvements, local government, local taxation, statistical returns.

Sanitary affairs are directly administered by local authorities :—

Counties—County councils.
Urban districts—Urban district councils.
County boroughs—Mayor.
Municipal boroughs—Municipal Councils.
Rural districts—Rural district councils.
Parishes (population 300)—Parish councils.

These local authorities employ their own executive officers, engineers, medical officers of health, sanitary inspectors, etc.

In India the supreme authority is the Local and Municipal department of Government, which has a staff of auditors, engineering and medical inspectors.

The local authorities are—

Municipal towns—Municipal councils.
Districts—District Boards.
Taluks—Taluk Boards.
Villages—Village unions, major and minor.

These authorities employ their own executive officers.

Duties of a Medical Officer of Health.

Administration of the Health Acts and sanitary laws and regulations in force; prevention of the spread of communicable diseases; improvement of the conditions of life among the poorer classes; investigation of all matters which may lead to the prevention of disease and the betterment of the social condition of the public. He requires a wide knowledge, not only of the causative factors of disease, but also of numerous practical details in connection with water-supply and drainage, food

supplies, building and architecture, law and statistics. Added to all this there must exist the tact and persuasive power, by which alone the best of schemes can be carried to a conclusion, and without which no mere knowledge of what ought to be done, even when backed by the force of the law, will avail.

Mankind resents coercion but may often be persuaded against its will.

Duties of Sanitary Inspectors.

The execution of all sanitary laws and regulations; execution of instructions of medical officers of health.

These duties involve a knowledge scarcely less varied than that of the medical officer of health, though of a different degree and often more detailed.

The Sanitary Inspector besides having to be familiar with the utmost possibilities of the available sanitary law, must possess a good working knowledge of all matters relating to sanitation, including infectious diseases and disinfection.

No practical detail connected with building, plumbing, architecture, the procedure in courts of law, slaughter of animals, veterinary medicine, engineering, and the processes of all kinds of manufactures is useless knowledge to him: he should know something about how every man earns his daily bread.

If he is to be successful he must be of unquestioned probity, and no less tactful, persuasive and diplomatic than the M.O.H., never overbearing or dictatorial; respectful, but never servile.

The existing Sanitary Law applicable in the Madras Presidency.

The sections of Madras Acts which deal directly with sanitation are abstracted below for ready reference.

THE MADRAS CITY MUNICIPAL ACT, III OF 1904.

DEFINITIONS.

SECTION.

3\. (1) "Bakehouse" means any place used for baking bread, biscuits or confectionery, from the baking or selling of which profit is sought.

(3) "Building" includes a wall and means any house, hut, shed, or roofed enclosure, whether used for the purpose of human habitation or otherwise.

(4) "Building line" means a line which is in rear of the street-alignment as defined in this section, and to which the main wall of a building abutting on a street may lawfully extend.

(7) "Dangerous disease" includes—

(*a*) Cholera, plague, small pox, diphtheria, enteric fever and typhoid fever; and

(*b*) any other epidemic, endemic or infectious disease which the Local Government may by notification declare to be a dangerous disease for the purposes of this Act.

(8) "Dangerous trades" includes those trade specified as dangerous in Schedule II, and any other trades which the Local Government may by notification declare to be dangerous trades for the purposes of this Act.

(11) "Drain" includes a sewer, a house-drain, a drain of any other description, a tunnel, a culvert, a ditch, a channel, and any other device for carrying off sullage, sewage,

offensive matter, polluted water, rain-water or sub-soil water.

3\. (14) "Horse" includes pony and mule.

(15) "House-drain" means any drain of, and used for the drainage of, one or more buildings or premises, and made merely for the purpose of communicating therefrom with a public drain.

(16) "Market" includes any place where persons may periodically assemble for the sale of meat, fish, fruit, vegetables or live-stock, or of edible produce of live-stock.

(19) "Nuisance" includes any act, omission, place or thing which causes or is likely to cause injury, danger, annoyance or offence to the sense of sight, smell or hearing, or which is or may be dangerous to life or injurious to health or property.

(20) "Occupier" includes any person for the time being paying or liable to pay, to the owner, the rent or any portion of the rent of the land or building in respect of which the word is used.

(21) "Offensive matter" means dung, dirt, putrid or putrifying substances, and filth of any kind which is not included in 'sewage' as defined in this section.

(22) "Offensive trades" includes those trades specified as offensive in Schedule II, and any other trades which the Local Government may by notification declare to be offensive trades for the purposes of this Act.

(23) "Owner" includes the person for the time being receiving or entitled to receive, whether on his own account or as agent or trustee for another person, the rent or

SECTION.

profits of the property, or in charge of the animal or vehicle in connection with which the word is used.

3. (24) "Populous Parts of the City" means such parts as the Local Government may, on the recommendation of the Standing Committee, declare to be populous.

(26) "Private street" means any street, road, square, court, alley, passage or riding-path which is not a "Public Street" as defined in this section, but does not include a pathway made by the owner of a building on his own land to secure access to, or the convenient use of, such building.

(27) "Public street" means any street, road, square, court, alley, passage or riding-path, whether a thoroughfare or not, over which the public have a right of way, and includes—

(*a*) the roadway over any public bridge or causeway,

(*b*) the footway attached to any such street, public bridge or causeway, and

(*c*) the drains attached to any such street, public bridge or causeway, and the land, whether covered or not by any pavement, verandah or other erection, which lies on either side of the roadway up to the boundaries of the adjacent property, whether that property is private property, or property reserved by Government for other purposes.

(28) "Railway" includes a tramway.

3\. (29) The expression "Re-construction," when used with reference to a building, includes—

(*a*) the reconstruction of a building after more than one-half its cubical extent has been taken down or burnt down, or has fallen down,

(*b*) the conversion of one or more huts or temporary structures into a masonry building, and

(*c*) the conversion into a place for human habitation of any building not originally constructed for human habitation.

Explanation.—Clause (*a*) applies whether the reconstruction takes place (after the commencement of this Act) entirely at the same time, or by instalments at different times, and whether more than half the cubical extent has (after the commencement of this Act) been taken down or burnt down, or has fallen down, at the same time or at different times.

(30) "Residence" means a dwelling used for day and night occupation, whether such occupation is continuous or not.

(32) "Rubbish" means dust, ashes, broken bricks, mortar, broken glass, kitchen or stable refuse, and refuse of any kind which is not offensive matter or sewage, as defined in this section.

(34) "Sewage" means night-soil, and other contents of latrines, urinals, cess-pools or drains.

SECTION.

(35) "Slaughter house" means any place used for the slaughter of cattle, sheep, goats or pigs, for the purpose of selling the flesh thereof as meat.

(37) "Street alignment" means a line dividing the land comprised in and forming part of a street from the adjoining land.

13. The Local Government may, in the event of any unusual mortality or the prevalence of any dangerous disease within the City, appoint temporarily a special Sanitary Officer for investigating the causes thereof, and advising as to the measures to be taken for the abatement or removal of such mortality or disease.

PART V.

PUBLIC HEALTH, SAFETY AND CONVENIENCE.

Water-supply.

192. Corporation shall provide a supply of wholesome drinking water and public fountains in the streets, and maintain the supply continuous and pure.

193. The owner of any building may, on reasonable application, be supplied with water for domestic purposes. This supply shall not include water for washing, trade, swimming baths, gardening, etc.

194. The owner may, on sending a written application, receive a water-supply for other than domestic purposes, for which payment shall be made.

197. Any channel carrying water to the city shall be fenced in.

SECTION.

198. Trespassers on land connected with conduit and water-supply shall be prosecuted. Penalty Rs. 20.

199. Dealing with violaters of preceding section.

200. Any constructions connected with water-supply are permissible, whether without or within the city.

201. All works connected with the water-supply, all constructions and all adjacent land shall vest in the Corporation.

202. In any project or construction without the City, the Corporation may exercise the same powers in execution of the work as within the city.

204. Pipes connected with water-supply may be carried through, across or under any street or other place.

206. Damage to any work connected with water-supply prohibited. Penalty Rs. 50.

207. Opening or removal of any part of the water-works, and drawing of water without permission prohibited. Penalty Rs. 50.

Drainage.

208. Provision and maintenance of drainage system; it shall be so constructed as not to be a nuisance.

209. All public drains and drainage works shall vest in the Corporation.

212. Power to improve drains; any person inconvenienced by any such improvement shall be provided with a drain at the cost of the Municipal Fund.

213. Sewage may be disposed of in any proper way with the avoidance of nuisance.

214. Right of owner or occupier to connect the house drains with municipal drains when permission has been obtained.

SECTION.

215. No connection of house drains with municipal drains permissible without sanction; power to close any such connection at the expense of owner or occupier. Penalty Rs. 200.

216. Unauthorised construction over drains prohibited. Penalty Rs. 100.

217. Power to direct owner or occupier to construct ditches, culverts, etc., at the expense of the said owner or occupier.

218. Power to enforce construction of house drains.

219. Power to permit and enforce connection between house drains.

220. Power to enforce drainage of a block of buildings by combined operation at the expense of the house or land owners.

221. Owner shall, within 15 days of notice received, make proper arrangements for catching and removing rain water. Penalty Rs. 50.

Public Latrines and Urinals.

222. Provision and maintenance of public latrines and urinals.

223. (1) Power to license, for period not exceeding one year, provision and maintenance of public latrines, etc.

(2) No public latrine or urinal can be kept without license. Penalty Rs. 50.

(3) Every licensee shall maintain latrine in proper order. Penalty Rs. 50.

Private Latrines and Urinals.

224. Owner or occupier of any building shall, within 14 days of receipt of notice, provide or alter and maintain in proper order any latrine, which must be so screened as to be hidden from view of passers-by. Penalty Rs. 50.

225. Every person employing workmen shall provide latrines and urinals and maintain same in good condition. Penalty Rs. 50.

226. Provision and maintenance of latrines and urinals by owner or manager of market, cart-stand, etc. Penalty Rs. 50.

227. All house-drains, private latrines, etc., shall be under the control of the Corporation; alterations, repairs, etc., to be made at expense of owner of building or land to which they belong.

Streets.

242. Any person intending to lay out a new street must send in written notice to Corporation with particulars as to level, width, etc., and all necessary arrangements.

247. Obstructions in streets or over drains prohibited. Penalty Rs. 100.

248. Power to direct removal of any encroachment made in any public street. Penalty Rs. 200.

249. Power to permit owner or occupier of any building to erect verandahs, balconies, etc. In time of festivals, etc., power to permit erections in public streets.

Building Regulations.

264. Any person intending to construct or reconstruct a building shall send in written application to Corporation for approval of site and permission to execute work, etc.

265. Power to refuse application of preceding section unless site is approved of.

266. Commencement of work prohibited unless written permission be granted on application sent under section 264.

271. Written application for the construction or reconstruction of a building may only be refused if the work or any of the particulars contravene some provision of this Act.

274. Power to visit building in construction within one month of receipt of notice given in section 143.

275. Power to require the owner to make alterations if the building is not in accordance with the plans approved of.

278. Any person desiring to construct a hut shall send in an application and plan of site.

Sanitation.

292. Provision by Corporation of receptacles for temporary or final deposit of rubbish, offensive matter, etc.

293. Power to direct all accumulated matter in any street or quarter to be deposited in convenient receptacles. Penalty Rs. 10.

294. Power to direct removal of large quantities of rubbish from any premises of trade and manufacture. Penalty Rs. 10.

295. Power to contract with the occupier of any building to remove sewage from any latrine, or rubbish from his premises on terms of payment.

296. The President shall provide for the removal of all deposits of rubbish accumulated under sections 292 and 293 and for daily cleansing of all streets.

297. All things deposited in receptacles provided under section 292 are the property of the Corporation.

298. Power to prescribe, in cases not provided for in section 294, the manner of removal of sewage, the route by which it shall be transported,

SECTION.

and the time at which such removal shall take place.

299. Maintenance of an establishment for the removal of sewage from latrines, etc., not connected with drains.

300. No person receiving a notice under sections 293 or 294 shall allow rubbish, etc., to accumulate for more than 24 hours. Deposit of rubbish, etc., otherwise than as detailed in notice under the same sections as above is prohibited. Removal of sewage, etc., otherwise than to a receptacle provided under sections 292 and 298 prohibited. No person shall throw rubbish, etc., in any place not appointed for purpose under section 292, or contrary to direction given under section 293. No owner or occupier of any building shall allow rubbish or any other offensive matter to accumulate for more than 24 hours in any quarter of the building, nor fail to comply with requisition as to cleansing or constructing of any latrine in or belonging to the building. No owner or occupier of any building shall allow the water of any sink, etc., or any liquid, to run down to any street, or the drain of any street, except in such a way as to avoid nuisance. Penalty Rs. 50; Rs. 10—20.

Inspection and Regulation of Places.

301. Power to direct owner of any private tank or well to cleanse the same and protect it from pollution; if the water is condemned as unfit for drinking, the owner shall refrain from using the water, or enclose or fence the tank. Penalty Rs. 50.

SECTION.

302\. Power to direct owner of any tank or well to cleanse or fill up the same, if it is found to be injurious to the health of neighbourhood, and to drain off or otherwise remove any stagnant pool, drain or cesspool. Penalty Rs. 50.

304\. Power to cleanse or fill up public well if injurious to the health of the neighbourhood.

305\. Power to secure and enclose any untenanted building, which has thereby become the resort of idle and disorderly persons. Penalty Rs. 50.

306\. Power to direct owner or occupier of any building to clear and cleanse the same from overgrowth and noxious vegetation within 24 hours of notice received. Penalty Rs. 50.

307\. Power to direct cleansing or limewashing of building. Penalty Rs. 50.

308\. Power to direct improvement of building and execution of such works in the building as may be deemed necessary for the prevention of risk to the health of the owner or occupier of the building, and the neighbourhood in general. Penalty Rs. 100.

309\. Power to apply to a Magistrate to condemn a building unfit for habitation until such causes as render it unfit are removed, when the former inhabitants may return. Penalty Rs. 20 daily.

310\. Power to apply to a Magistrate to abate the overcrowding in rooms; it is incumbent on the tenant or lodger of such rooms to vacate on being required so to do by the owner. Penalty Rs. 20 daily.

311\. Power to prohibit fishing in any water if such fishing is likely to be injurious to the health of the public. Penalty Rs. 20.

SECTION.

Keeping of Animals.

312. No person without permission shall keep swine in any part of the city or any other animal on his premises which is likely to be dangerous or a nuisance ; no animal shall be fed with sewage or offensive matter. Penalty Rs. 50 ; Rs. 10.

313. A person authorised in writing may destroy stray swine.

314. The owner of any livery stable, cart-stand, etc., or of any yard in which goats or cattle are kept, in the first month of each year or the month before the opening of such a place, shall apply for a license for the use of the same. Power to grant or refuse such license. This section shall not apply to any of the above-mentioned places under Government control. Penalty Rs. 50.

315. Power to control all stables, cattle-sheds, etc., power to require alteration, disinfection, cleansing, etc., to any of the above mentioned, at the expense of the owner.

316. Power to discontinue the use of any stables, cattle-sheds, etc., as such, if the construction and maintenance thereof are not in accordance with the manner prescribed in this Act. Penalty Rs. 50.

317. Upon the death of an animal, the occupier of the premises shall either remove the carcase within 3 hours of its death, or report the death to the Health Officer with a view to his causing the same to be removed, at the expense of the owner, or the occupier of the premises. Penalty Rs. 20.

Public Bathing and Washing.

318. Provision of places for washing animals.

SECTION.

319. Prohibition against bathing in any water set apart for drinking purposes, against washing animals or clothes in such water, against throwing any animal into or allowing one to enter such water, against doing anything whereby the water may be fouled. Penalty Rs. 50.

Factories and Trades.

320. Prohibition against fouling the water of any tank, stream or reservoir in carrying on any trade or manufacture. Penalty Rs. 1,000.

321. Power to lay open and examine any works or pipes connected with trade or manufacture. If water has been fouled, expenses of examination are paid by the owner or person connected with the trade; if on examination the water is found not to have been fouled, expenses of examination shall be paid by the Corporation.

322. Owner or occupier of any place used for dangerous or offensive trades must at the begining of each year or before the opening of such a place apply for a license. Power to grant or refuse such license, provided that this occupation is not under Government control. Prohibition against the use of any such place without license. Penalty Rs. 200.

324. Prohibition against the erection of smoke producing or dangerous machinery. Penalty Rs. 50.

325. License shall be obtained yearly for the sale or storage of wood, coal, straw or any other combustible thing. Penalty Rs. 100.

328. License shall be obtained at the beginning of each year by owner or occupier of a

SECTION.

bake-house or manufactory of ice or aerated waters. Penalty Rs. 50.

329. Provision of public washing places, and fees for the use of the same.

330. Prohibition against washing in any other place than that provided for the purpose either within or without the city. Penalty Rs. 20.

Slaughter-houses and Markets.

331. Provision of a sufficient number of slaughter-houses, and fixation of fees for the use of the same. With the sanction of the local Government these may be situated within or without the city.

332. The owner of any such place shall, at the beginning of each year, apply for a license; power to grant or refuse such license. Penalty Rs. 200.

333. Power to permit special slaughtering places on special occasions.

334. No person without license shall slaughter any animal for sale or food, or allow any skin to be dried which may cause a nuisance. Penalty Rs. 20 each animal.

335. Power to permit slaughter of animals without license or fee, for religious ceremony.

336. All markets repaired or maintained by Corporation shall be public markets.

337. Provision of public markets and fixation of fees for the use of the same.

341. Power to close or sell public markets.

342. Prohibition of sale in public market without license. Penalty Rs. 50.

343. Prohibition against establishing private market without license. Penalty Rs. 500.

344. No person shall, without license, keep open a private market. Such license may be

SECTION.

refused or granted; the license may be withheld till the owner or occupier executes such work as specified in the order. Notice of such license to be fixed up. Penalty Rs. 500.

346. Sale of any sort in unlicensed private market prohibited. Penalty Rs. 50.

347. Power to require the owner or occupier of any private market to build any necessary constructions, to maintain the market in good condition, to keep it well ventilated, watered and clean. Penalty Rs. 50.

348. Any person failing to carry out the requirements of the preceding section shall have his license suspended. Penalty Rs. 50 daily.

349. Power to make regulations for the prevention of nuisances in any public place, for fixing the time at which markets, etc., may be opened, for keeping such places in good condition, well ventilated and watered. Penalty Rs. 50.

351. Prohibition against the sale of articles in public streets. Penalty Rs. 20.

Food and Drugs.

352. Power to enter any place where unlawful slaughter of animals or sale of flesh is suspected.

353. Provision for constant inspection of animals, fruit, vegetables or any article exposed for sale for human consumption.

354. Power to seize any animal or article of any sort, if they appear to be unsound and unfit for human food. Meat subjected to the process of blowing is unfit for human consumption.

SECTION.

355. Any articles seized under section 354 shall be destroyed with or without the consent of the owner at his expense.

356. Any animal or article seized under section 354, and not destroyed in pursuance of section 355, shall be taken before a Magistrate who shall dispose of it as he may deem fit.

357. Prohibition against sale of articles of food or drugs not of the nature demanded. Penalty Rs. 100.

358. Prohibition against the sale of improperly compounded articles of food or drugs. Penalty Rs. 100.

359. Prohibition against the abstraction from any article of food any part which will affect the quality thereof, and selling such articles without disclosing the alteration. Penalty Rs. 100.

360. Power to purchase any food or drug for analysis. Penalty for refusal to sell Rs. 50.

361. Power to take the sample purchased according to section 360, before a Magistrate if, on analysis, offence against the provisions of this chapter has been committed.

Restraint of Infection.

362. Provision and maintenance of properly established hospitals within or without the city, for the treatment of infectious diseases.

363. Obligation of all medical practitioners to report dangerous disease. Penalty Rs. 50.

364. Power to enter, with or without notice, any place in which infectious disease is suspected to exist.

SECTION.

365. Provision of conveyances for the patients.

366. Power to order the removal of patients to the hospital.

367. Power to require the cleansing or disinfecting of any building, so as to prevent the spread of any disease. In default of compliance of the owner with the above, the Corporation shall cause the work to be done at the expense of the owner. Penalty Rs. 50.

368. Provision and maintenance of places for the disinfection of articles, clothing, bedding, etc. Any loss of articles through disinfection shall be compensated.

369. Prohibition against the loan, sale or hire of any article which has been exposed to infection. No article shall be thrown away which has been exposed to infection without being first disinfected. Penalty Rs. 50.

370. Prohibition against persons suffering from dangerous diseases entering public conveyances without proper precaution; no owner or driver of a conveyance shall knowingly carry a person suffering from a dangerous disease in his conveyance, in contravention of the above. Penalty Rs. 50.

371. No owner or driver of any conveyance shall take any person suffering as aforesaid until all expenses incurred by disinfection shall be covered.

Vaccination.

374. Power to declare by notification that vaccination throughout the city shall be compulsory.

Registration of Births and Deaths.

SECTION.

375. Maintenance of registers of births and deaths and appointment of Registrars.

376. Every Registrar appointed shall reside in some central part of the city and shall cause his name to be affixed to his residence.

377. Provision of registers for the entries of births and deaths.

378. Duty of the Registrar to inform himself of every birth or death within his district.

379. Duty of the person responsible for the child, legitimate or otherwise, to give information of its birth within a week of the same. Penalty Rs. 20.

380. In the case of a child born in a hospital, the duty rests with the medical officer to send a report of the birth to the Registrar. Penalty Rs. 20.

381. Within 36 hours of the death of a person, the nearest relative, a person present at the death, or some person living in the house, shall give information to the Registrar concerning the death of the person. Penalty Rs. 20.

382. Obligation of the medical man to give notice of a death. Penalty Rs. 20.

383. Obligation of the person performing the funeral ceremonies to give notice of the death. Penalty Rs. 20.

384. Any person giving information shall sign his name, occupation and residence in the Register and shall receive an authenticated extract from the register. Penalty Rs. 20.

Disposal of the Dead.

SECTION.

385. The owner of any place used for the disposal of the dead shall apply to the Corporation for registration of the same, giving at the same time all particulars concerning the place and the owner. Power to grant or refuse registration.

386. Registration on closing of ownerless places.

387. No new burial-ground shall be opened without license, which may or may not be obtained on application.

388. Places registered or licensed under the last three sections shall be recorded in a register. Notification of such places shall be affixed in a conspicuous spot near the entrance to the burial-ground.

389. Prohibition against disposal of bodies in unregistered and unlicensed places. Penalties Rs. 100 and Rs. 500.

390. Owner of burial-ground shall report any burials or burnings to the officer in charge. Penalty Rs. 20.

391. Prohibition against making a vault or grave in or underneath a place of worship. Penalty Rs. 500.

392. Power to close any burial or burning ground which may be considered dangerous to the health of the neighbourhood, or if any such place be overcrowded. Penalty Rs. 200.

393. Prohibition against burial and burning contrary to this Act, or its by-laws. Penalty Rs. 50.

394. Every grave digger must receive a license. Penalty Rs. 20.

395 & 396. Provision of a sufficient number of burial or burning grounds within or without the city; such places shall be maintained under the provisions of this Act.

By-laws and Rules.

SECTION.

409. Power of the Corporation to make by-laws for—

(6) the measurement of water for domestic and other purposes, for tanks, wells and other places or works for water-supply;

(7) the regulation of buildings and laying out of streets;

(9) the connection of house with Municipal drains, and the procedure to be followed by the owner or occupier;

(10) the specification of materials to be used in the construction of drains;

(11) the construction and maintenance of any drains, pipes, cess-pools and drainage works of every description;

(12) the maintenance of a map of the drainage system, and the giving of facilities for the inspection of the same;

(13) the inspection and control of places where dangerous or offensive trades are carried on;

(14) the control and supervision of slaughter-houses within or without the City;

(15) the control, regulation and inspection of all public or private markets, shops, etc., and of the sanitary condition of the same;

(19) the prevention of the sale of unwholesome meat, and efficient inspection of shops in which are sold articles and food for human consumption;

(20) the manner in which stables, cattle-sheds, etc., are to be constructed and connected with Municipal drains;

SECTION.

(21) the inspection of milch cattle, and the prescribing and regulation of lighting, cleansing, drainage and water-supply of dairies and cattle-sheds;

(22) enforcing cleanliness in anything used for containing milk;

(23) requiring notice to be given whenever any milch animal is affected with a contagious disease, and for preserving such animals against infection;

(24) the prevention of dangerous diseases to men or animals;

(25) the regulation of lodging houses;

(26) the enforcement of compulsory vaccination;

(27) the regulation of burial or burning-grounds and the levy of fees for the same;

(28) the registration of births and deaths.

410. Power to levy a fine for the breach of by-laws.

Scavengers.

425. One month's notice before discharge, or one month's wages in lieu thereof, shall be given to every scavenger employed by the Corporation, unless he is discharged for misconduct or engaged for a specified term and leaves at the end of it; should any such person leave without giving the notice required or refuse to perform his duties, he shall be liable to a fine or two months' imprisonment. This also applies to other municipal servants.

Service of Notices.

435. When any notice is required to be served on any owner or occupier of any building or

SECTION.

land, it shall not be necessary to name the owner or occupier in the document; if there is more than one, such a document may be given to any of them, or, if they are not found, to any member or servant of the family or affixed to the building.

436. If any such document is required to be given to any person otherwise than the owner or occupier, it shall be either given or posted to him, or given to a member or servant of the family, or affixed to the building.

Power of Entry.

440. Power to enter any building or land to make inquiry or inspection, or to execute work authorised by the provisions of this Act.

Prosecutions.

451. Power to prosecute any person for the breach of any of the provisions of this Act.

452. No person is liable to punishment for any offence unless an appeal be made to a Magistrate within six months after the commission of the offence.

Police.

462. Duty of police to communicate any information concerning the commission of any offence against this Act; to render assistance to any member of the Corporation when such should be needed.

463. Power to arrest any person suspected of giving a false name and address, or refusing to give any name. No such person shall be detained in custody after his name and address are ascertained, or without the order of a Magistrate.

SECTION.

464. The Local Government may permit the exercise of powers of a Police officer by Municipal servants.

SCHEDULE II.

DANGEROUS AND OFFENSIVE TRADES AND OTHER PURPOSES FOR WHICH PREMISES MAY NOT BE USED WITHOUT LICENSE.

(b) *Offensive Trades.*

(1) Boiling camphor, paddy or oil.
(2) Washing soiled clothes.
(3) Storing, packing, pressing, cleansing, preparing, or manufacturing by any process whatever, any of the following articles, namely :—

Blood.	Hides.	Pitch.
Bones.	Hoofs.	Rags.
Catgut.	Horns.	Skins.
Fins.	Leather.	Soap.
Fish.	Manure.	Tar.
Hair.	Offal.	Turpentine.

(c) *Other purposes for which Premises may not be used without License.*

(1) Casting metals.
(2) Manufacturing bricks, pottery or tiles.
(3) Horse-slaughtering.
(4) Manufacturing articles from which offensive or unwholesome smells, fumes or dust arise.
(5) Manufacturing or distilling sago.
(6) Packing, pressing, cleansing, preparing or manufacturing by any process whatever, any of the following articles, namely :—

Cloths in indigo or other colours.
Paper.
Pottery.
Silk.

(7) Storing, packing, pressing, cleansing, preparing or manufacturing by any process whatever, any of the following articles, namely :—

Candles.	Jute.
Cocoanut fibre.	Meat.
Cotton or cotton refuse and seed.	Oil.
	Oil cloth.
Fat.	Rosin.
Flax.	Spirits.
Flour.	Surkhi.
Hemp.	Tallow.
Iron.	Wool.

SCHEDULE XII.

Building Rules.

1. The floor or lowest floor of every building, constructed or reconstructed from the ground level, must be constructed at such level as will admit of the construction of a drain sufficient for the effectual drainage of the building, and placed at such level as will admit of the drainage being led into some public drain at the time existing, or projected.

4. The plinth of a masonry building must be at least 18 inches above the level of the centre of the nearest street.

12. The height of a masonry building shall in no case exceed the width of the street in which it is constructed.

3. Every room in a domestic building which is intended for human habitation

   (*a*) must be in every part not less than 9 feet in height, measured from the floor to the under side of the beam on which the roof rests ;

   (*b*) must have a clear superficial area of not less than 80 square feet ; and

(*c*) must be provided, for purposes of ventilation, with doors or windows opening directly into the external air, or into a verandah.

14. (1) There must be in the rear of every domestic building an open space extending along the entire width of the building and belonging exclusively to the building, unless the back of the building abuts on an open square or the like, of not less than 20 feet in width, which is dedicated to public use and is consequently not likely to be built upon.

(2) The minimum distance across such space from every part of the building to the boundary line, or (if the boundary is a wall) the inner edge of the boundary wall, of the building or land immediately opposite such part, shall be 10 feet.

16. (1) Every interior courtyard must be raised at least one foot above the level of the centre of the nearest street, so as to admit of easy drainage into the street.

(2) Every interior courtyard and every such open space must be open to the sky throughout its entire area, and no structure shall be erected within or above, or so as to project over, the same.

17. Every application for approval of a building must be written on a printed form, must state such particulars as are prescribed by the Corporation, and must be accompanied with a site plan giving full particulars of dimensions, etc.

18. Any application for permission to construct or reconstruct a building must be sent as prescribed in the preceding section, giving full information as to particulars required.

22. Except with the permission of the President, no portion of a hut shall be placed within 6 feet of a masonry building :

Provided that this rule shall not preclude the construction of huts in compounds in any case where masonry out-offices would be permissible.

23. No hut shall be of more than one storey or shall exceed 12 feet in height, measured from the top of the plinth to the junction of the eaves and wall.

24. The plinth of a hut must be raised at least one foot above the level of the centre of the nearest street or passage.

25. Huts must be built in continuous lines, in accordance with an alignment to be prescribed by the President, and demarcated on the ground.

26. Where an alignment prescribed under rule 25 does not correspond with the alignment of a street, a passage of at least 12 feet, measured from eave to eave, must be left between the rows of huts abutting on such prescribed alignment.

27. All passages referred to in rule 26 shall remain private property, subject to a right in the municipal authorities to send carts along them, or otherwise make use of them for any of the purposes of this Act.

28. Notwithstanding anything contained in rule 25, huts may, with the special sanction of the President, be built so as to form an open courtyard, comprising at least one-fourth of the whole area occupied by the huts and courtyard.

29. There must be between all huts, except in the case of huts referred to in rule 28, a space of at least 3 feet, measured from eave to eave.

THE MADRAS DISTRICT MUNICIPALITIES ACT, No. IV OF 1884.

[*As modified up to 1st February 1908.*]

"DEFINITIONS."

SECTION.

3. (v) "Hack-stable" means any place where a horse is ordinarily kept for hire.

(vii) "Inhabitant" means any person who shall have been ordinarily residing in any Municipality for a period of six months or upwards.

(viii) "Inoculation" means any operation performed with the object of producing the disease of small-pox by means of variolous matter.

(ix) "Latrine" includes privy.

(xii) "Public market" means any market belonging to the Municipal Council or constructed, repaired or maintained out of the Municipal Fund.

(xiii) "Private market" means any other market.

(xvi) "Notice" means a written, printed or lithographed notice.

(xxiv) "Scavenger" means a person employed in collecting or removing night-soil, in cleansing drains or slaughter-houses, or in driving carts used for the removal of night-soil.

(xxvii) "Street" includes any road, street, square court, alley or passage, whether a thoroughfare or not, over which the public has a right of way, together with the drains on either side, and with the land, whether covered or not by any

SECTION.

pavement, verandah or other erection, which lies on either side of the roadway up to the boundaries of the adjacent property, whether that property be private property or property reserved by Government for other purposes; and also includes the roadway over any public bridge or causeway.

3. (xxix) "Unprotected child" means a child who has not been protected from small-pox by having had that disease, either naturally or by inoculation, or by having been successfully vaccinated, and who has not been certified in the manner herein-after provided to be insusceptible of vaccination.

(xxx) "Vaccinator" means a public or private vaccinator.

(xxxi) "Public vaccinator" means any vaccinator employed under this Act by a Municipal Council.

(xxxiii) "Water-course" includes any river, stream or channel, whether natural or artificial.

(xxxiv) "Public water-courses, springs, wells and tanks" include those used by the public to such an extent as to give it a prescriptive right to such use.

Definitions which are found in the Madras City Act are not reproduced here.

32. The Chairman is the chief executive officer of the Municipal Council.

33. The Collector of the District may execute any resolution on default of the Chairman.

34. The Collector has inspecting powers.

35. The Government or the Collector may suspend action.

75. Water tax on buildings and lands.

SECTION.

125. Provision and maintenance of hospitals and dispensaries.

VACCINATION.

129. Provision for gratuitous vaccination.
133. Government may declare vaccination compulsory;
134. when every child over 6 months or under 10 years of age must be vaccinated.
138. Penalty of Rs. 50 and Rs. 10 a day for disobedience of notice to have child vaccinated.
142. Prohibition of inoculation. Penalty of 3 months' imprisonment or fine of Rs. 200 or both.

WATER-SUPPLY.

143. Municipal Council shall, so far as funds admit, provide a sufficient supply of water fit for domestic use.
144. The Council may, with the sanction of the Government, construct new works, and may maintain, close or alter existing works.
150. Any person trespassing on Municipal land belonging to any water-supply, or connected in any way with the water-supply, shall be liable to a fine not exceeding Rs. 20; and if unwilling to leave such land, may be removed by force, and shall be liable to a further fine not exceeding Rs. 50.
151. Any person damaging in any way any channel, fountain, tank, etc., connected with the water-supply or unlawfully drawing off water from the works shall be liable to a fine of Rs. 20.
152. Penalty of Rs. 500 and Rs. 100 a day for fouling water by offensive trades.

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154. Council may set apart tanks, wells, etc., for drinking purposes, and for bathing or washing animals or clothes.

155. Penalty for fouling drinking water sources, public or private in any way, Rs. 20.

156. Power to require private well, tank, stream, etc., to be cleaned and kept in order or to be closed, if unfit for drinking.

STREETS.

157. Maintenance and repair of streets.

162. Power to require any work connected with levelling, paving, draining, etc., any street, to be carried out by the owners or occupiers of the land within specified time.

167. Power to forbid obstructions and bounding walls to be made without permission; power to require the owner or occupier of any building to make any necessary alterations.

175. Watering and lighting streets.

180. Any person desiring to construct a well or building shall apply to the Corporation for a license, giving all particulars concerning the construction. Such license may be granted or refused.

181-A. Prevention of crowding of huts.

184. Power to require owner to enclose or cleanse deserted buildings or lands.

186. Power to direct the removal of any noxious vegetation or overgrowth; power to require owner or occupier of any building to lime-wash the same.

187. Power to direct owner or occupier of any building to execute such works as are deemed necessary for good drainage, ventilation, etc. On refusal of the owner or occupier, power to have such works executed at the expense

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of the aforesaid, or to pull down such buildings, in which case compensation shall be made to the owner.

OFFENSIVE AND DANGEROUS TRADES.

188. Power to forbid the continued exercise of certain trades without license ; such as—
Washing clothes.
Boiling paddy, camphor, oil.
Melting tallow, sulphur.
Storing offensive materials of any description.
Making fish oil, bricks, pottery, lime, etc.
Manufactories which cause offensive odours.
The storage of explosive materials.
Purposes which are dangerous to the neighbourhood.
Stables, sheds, cattle yards.
Preparation of flour, or anything connected therewith.
Manufactory of ice and aerated waters.
Sale or storage of timber, hay, grass, coal, or of dairy produce.

189. Penalty for using such places as the above without license, Rs. 100.

SLAUGHTER-HOUSES.

191. Municipal Council to provide slaughter-houses or places. Such must be licensed, and fees charged for the slaughter of all animals.

192. Penalty for slaughtering elsewhere or drying skins so as to cause nuisance, Rs. 20.

MARKETS.

194. Municipal Council may provide markets.

196. Private markets must be licensed.

SECTION.

200. Any owner or occupier of any private market shall make such alterations and constructions, or provide such water-supplies as the Council shall direct.

203. Power to prohibit the sale of any article upon any specified street. Any person selling against such notification is liable to a fine of Rs. 10.

204. Power to enter any place for inspection of articles sold for food. If such articles are deemed unfit for consumption they may be brought before a Magistrate who shall determine the condition, good or bad, of these articles. If the seller suffer loss through wholesome articles being brought for inspection, compensation shall be made to him.

LATRINES.

206. Municipal Council shall, so far as funds admit, provide and maintain a sufficient number of public latrines and urinals.

207. Owner or occupier of a building or of ground on which a block of six or more huts stand, may be required to provide or alter and properly maintain a latrine.

208. Latrine must be provided when more than 20 labourers are employed.

209. Power to contract with owners of property to construct or repair drains, etc., in their property.

DRAINS.

210. Drainage works to be constructed under the direction of Municipal Council.

211. No person shall, without written permission, alter, obstruct or in any way interfere with public drains, whether they pass through public or private grounds.

SECTION.

212. Buildings over sewers, etc., shall not be erected without the written permission of the Council.

213. No drain, privy, or cess-pool shall be constructed without permission of Council.

214. Branch drains, private latrines, cess-pools, etc., to be under the control of Council and kept in order at cost of owners.

SANITARY REGULATIONS.

216. Arrangements shall be made for the removal of night-soil, rubbish, ashes and any offensive matter; provision of rubbish depots, vehicles for the removal of all rubbish and offensive matter.

217. Power to order the provision of movable receptacles for night-soil and other offensive matter; on failure to comply, such provision shall be made at the expense of the occupier.

218. Power to contract with the owner or occupier of any building for the removal of rubbish and all offensive matter.

219. Any person depositing night-soil, rubbish, or offensive matter of any kind in any other place than that provided in the preceding sections shall be liable to a penalty of Rs. 10 for each offence.

220. Penalty for failure to use receptacles when they have been provided.

221. Prohibition against keeping offensive matter of any sort on the premises for more than 24 hours. Penalty Rs. 20.

222. Prohibition against allowing liquid matter from any sink, drain, stable, etc., to flow out into any place except a drain, so that it shall become a public nuisance. Penalty Rs. 10.

SECTION.

223. Prohibition against using any cart without a cover for the removal of night-soil, or the careless removal of the same. Penalty Rs. 20.

224. Penalty for throwing rubbish, etc., into sewers or drains. Rs. 20.

225-A. Prohibition against feeding animals on deleterious substances. Penalty Rs. 50.

226. Power to prevent overcrowding in buildings, if such is dangerous to the health of the occupiers. Any person neglecting an order against overcrowding shall be liable to a fine of Rs. 10 for every day of the committal of the offence.

227. Maintenance of public wells and tanks by the Council; power to fill them up when necessary.

228. Owners may be required to cleanse, fence, repair or fill up tank, well or drain of stagnant water.

228-A. Power to prohibit cultivation which may appear to be dangerous to the neighbourhood. Compensation shall be made for damage caused by prohibition.

230. Stray pigs and dogs may be destroyed.

230-A. Prohibition against keeping pigs which are a nuisance to the neighbourhood. Penalty Rs. 10.

PREVENTION OF INFECTIOUS DISEASES.

231. Power of entry to prevent spread of disease, and to disinfect houses at the owner's or Municipal expense.

231-A. Prohibition against disposal of any articles which have been exposed to infection and which have not been disinfected.

232. Places for washing infected articles may be appointed or such articles may be destroyed.

SECTION.

Penalty for washing in any other place than that provided Rs. 50.

232-A. Power to prohibit the use of any uncleanly wells or tanks.

233. Power to order the removal of patients to hospital on medical authority.

233-C. Prohibition against letting any house or part of a house which has become infected by some dangerous disease. Penalty Rs. 200.

DISPOSAL OF CORPSES.

234. Municipal Council shall provide burning or burial grounds.

238. Penalty for disposing of corpse elsewhere.

241. Depth of grave; distance between graves; re-opening graves; burial and cremation to begin within 6 hours of the arrival of the corpse at the burning or burial ground; cremation to be complete; clothes to be burned; corpses carried through streets to be decently covered; leaving the corpse on a highway; removal of corpse kept for dissection. Penalty Rs. 50.

242. All grave-diggers shall be licensed.

243. Municipal Council to keep registers of births and deaths and to appoint registrars.

247. Father or mother or some one present at birth to give information within a week. Some one present at death, or in attendance during illness, or occupier of house, to give information of death within 24 hours.*

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* It is noticeable that no penalty for default is contained in the Act, though such was provided in the Local Boards Act, 1871. But under section 255 of the present Act, a by-law may provide a penalty of Rs. 50.

SECTION.

MISCELLANEOUS.

255. Power to make by-laws :—

(iii) for the management of markets, etc., burial or burning grounds, of offensive trades ; regulating the planting of trees, etc. ;

(iv) for securing cleanliness and order in streets ;

(v) carrying out purposes of this Act ;

(vi) securing the good government and well-being of the Municipality.

282. Police officers to report offences to Municipal Council ; power to arrest persons committing offence in view.

282-A. Scavengers entitled to notice of dismissal.

THE MADRAS HILL MUNICIPALITIES ACT

ACT II OF 1907.

Contains a few extra sanitary sections which do not find a place in the District Municipalities Act, but are included in the Madras City Act of 1904.

THE MADRAS LOCAL BOARDS ACT

No. V OF 1884.

AMENDED BY No. VI OF 1900.

District Boards, Taluk Boards and Panchayats have been constituted by this Act for the purposes of local Government, including village and district sanitation.

144. Government may, from time to time, make rules as to the duties, responsibilities and mutual relations of those bodies.

The following is a brief account of the constitution of Local Boards and Panchayats as formed under this Act :—

District Boards.

Authority over each district is vested in a District Board, which consists of a President and at least 24 members. The Collector is *ex-officio* President, unless Government has authorized the election of the President; and every revenue officer in charge of a division is a member. The other members may all be appointed by Government or be in part elected; but not more than one-fourth may be officials.

Taluk Boards.

The local authority of each taluk is a Taluk Board, which is in a manner subordinate to the District Board. The revenue officer in charge of the division of the district in which the taluk is situated is *ex-officio* President, unless Government has authorized the election of the President. The Board must consist of at least 12 members, who may be appointed wholly by Government or partly by election. Not more than one-third may be officials. Meetings must be held at least once a month. A Board may be abolished by order of Government. The President of a Local Board is its chief executive officer.

Panchayats.

Any village or group of villages may, from time to time, be constituted a *union* by notification of Government. *Major unions*

have a population over, *minor unions* under, 5,000. Each union is controlled by a *Panchayat* of not less than five members. The headman of each village in a union is *ex-officio* a member. The other members may be appointed by Government or be in part elected. Government may appoint a chairman or authorise his election.

A Panchayat is the agent of and under the control of the Taluk Board.

This Act and its amendment sets forth the powers and duties of the District Boards, Taluk Boards and Panchayats, including sanitary administration. The powers are similar to those granted in the District Municipalities, but are somewhat more limited.

INDIAN PENAL CODE

ACT XLV OF 1860.

(*As modified up to 1st August 1890.*)

CHAPTER XIV.

OF OFFENCES AFFECTING THE PUBLIC HEALTH, SAFETY, CONVENIENCE, DECENCY AND MORALS.

268. A person is guilty of a public nuisance, who does any act, or is guilty of an illegal omission, which causes any injury, danger or annoyance to the public or to the people in general who dwell or occupy property in the vicinity, or which must necessarily cause injury, obstruction, danger or annoyance to persons who may have occasion to use any

SECTION.

public right. A common nuisance is not excused on the ground that it causes some convenience or advantage.

269. A negligent act likely to spread the infection of any disease dangerous to life is punishable by 6 months' imprisonment, which may be with hard labour, or by fine, or both.

270. A malignant act likely to spread the infection of any disease dangerous to life is punishable by 2 years' imprisonment, which may be with hard labour, or by fine, or both.

271. Disobedience to a quarantine rule is punishable by 6 months' imprisonment, or fine, or both.

272. Adulteration of food or drink intended for sale, so as to make it noxious, is punishable by imprisonment for 6 months, or a fine of Rs. 1,000, or both.

273. Sale of noxious food or drink (knowingly) is punishable by similar penalties.

274. Adulteration of drugs so as to lessen their efficiency or change their operations or make them noxious, carries similar penalties.

275. Sale of adulterated drugs or (276) of any drug as a different drug or preparation, is similarly punishable.

277. Fouling the water of a public spring or reservoir * is punishable by 3 months' imprisonment, or fine of Rs. 500, or both.

278. Making atmosphere noxious to health is similarly punishable.

284. Negligent conduct with respect to any poisonous substance is punishable by 6 months' imprisonment, or fine of Rs. 1,000, or both.

* This does not include a river.

SECTION.

290. Punishment for public nuisance (in any case not otherwise punishable by this Code), fine up to Rs. 200.

291. Continuance of nuisance after injunction to discontinue is punishable by 6 months' imprisonment or fine, or both.

CODE OF CRIMINAL PROCEDURE

ACT V OF 1898.

54. Any police officer may, without an order from a Magistrate, and without a warrant, arrest any person who has been concerned in any cognisable offence, or against whom a reasonable complaint has been made, or credible information has been received, or a reasonable suspicion exists, of his having been so concerned.

PUBLIC NUISANCES.

133. A conditional order for the removal of a nuisance, obstruction, or injurious trade, may be made by a District Sub-divisional or duly empowered First-class Magistrate.

135. Person to whom order is addressed may obey it, or show cause against doing so, or apply to the Magistrate for a jury to try it.

136. On default, person is liable to penalty under section 188, Penal Code, and order shall be made absolute.

140. When an order has been made absolute, the person is to be required to perform the act within a given time; on default he is liable to penalty by section 188, Penal Code.

If such act is not performed within the time fixed, the Magistrate may cause it to be

SECTION.

performed, and may recover the cost from the person.

142. To prevent imminent danger or injury of serious kind to the public, a Magistrate making an order under section 133 may issue such injunction as may be required. In default he may adopt such means as he thinks fit to prevent it.

143. A Magistrate may order any person not to repeat or continue a public nuisance, as defined in the Indian Penal Code or any special or local law.

144. An absolute order may be issued at once in urgent cases of nuisance.

149. Every police officer shall interpose to prevent the commission of any cognisable offence.

151. If necessary, he may arrest without warrant, to prevent commission of any such offence.

155. Non-cognisable offences can only be investigated by, or under orders of, a Magistrate.

THE EPIDEMIC DISEASES ACT

ACT III OF 1897.

An Act to provide for the better prevention of the spread of Dangerous Epidemic Disease.

The Governor-General in Council has power to take special measures and prescribe regulations to prevent the outbreak or spread of a dangerous epidemic disease. Any person disobeying regulations or orders made under this Act is punishable under section 188, Indian Penal Code. The plague regulations are formulated under this Act.

APPENDIX.

Comparison of English and Metrical Weights and Measures.

1 metre	=	39·37 inches.
1 millimetre	=	0·3937 inches.
1 inch	=	2·54 centimetres.
1 mile	=	1·6093 kilometres.
1 square metre	=	10·76 square feet.
1 litre	=	1·0 cubic decimetre.
	=	1,000·0 cubic centimetres.
	=	61·025 cubic inches.
	=	35·3 fluid ounces.
1 cubic foot	=	1.000·0 fluid ounces.
	=	6·23 gallons.
1 cubic metre	=	35·316 cubic feet.
1 gram	=	15·43 grains.
1 kilogram	=	2·2 pounds avoirdupois.

To convert the Centigrade thermometric scale to the Fahrenheit scale, multiply by $\frac{9}{5}$ and then add 32. To convert Fahrenheit to Centigrade, subtract 32 and then multiply by $\frac{5}{9}$.

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